Perceptions of product innovativeness and desirability : the influence of an education in design

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Background Although previous research has contributed to the development of the concept of design innovation, a lack of understanding related to how people actually perceive design innovation still exists. This study aims to investigate perceptions of innovation, and how these perceptions may differ as a result of such factors as background and education.

Methods Eleven products were selected from among the winners of the 2012 Reddot design awards as examples of innovative product design. Twenty design students and twenty students from a non-design background assessed the innovativeness and desirability of each product using a 5-point Likert scale. Based on Rampino's innovation framework (2011), innovativeness of Form, Technology, and Mode of Use were assessed together with holistic innovativeness.

Results The design and non-design students showed significant differences in their perceptions of holistic innovativeness, F (1,38) = 4.372, p < .05. They also perceived Mode of Use differently, indicated by an interaction effect between their major and the types of product they assessed. The results of a correlation analysis between innovativeness and desirability showed that holistic innovativeness is positively related to desirability. In contrast, innovativeness of Technology has a relatively weak relationship to product desire.

Conclusion A greater understanding of how design innovation is perceived provides useful insights which may then be utilized in the design and development of more desirable, innovative products. In this regard, the investigation provides a foundation for successive studies to link the conceptual principle of design innovation to real-world innovation as it is perceived and experienced by the user.

Keywords Design innovation, innovativeness, perception difference, desirability

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1. Introduction

Over the last 30 years, much research related to 'design' and 'innovation' has been undertaken. In its infancy, earlier studies in design innovation were conducted in the field of management to investigate design as a strategic tool from the perspective of financial benefit and economy (Walsh et al, 1988). Due to increasing research however, the definition of design innovation has gradually broadened from 'incremental novelties in design' to 'innovation by design' (Mutlu et al, 2003, Verganti, 2009).

For example, Verganti (ibid) describes design-driven innovation as the radically changed meaning of a product. He goes on to present several examples of radical innovation through design including the Nintendo Wii and the Metamorphosi lighting system by Artemide.

In a study to explore the concept of design innovation and its application and use in the development of new products, Rampino (2011) proposes a structurized framework as a means to describe design-driven innovation. Through this study Rampino introduces three innovation levers as a fulcrum for four different innovation results. These levers are described as starting points for the design-driven innovation process.

Form   Tech   Mode of Use

Figure 1 Examples of design–driven innovations that used each lever as a starting point (Rampino, 2011)

The Form lever suggests a new aesthetic value and a new language for the product by considering its figurative attributes. For example, Pipedream the Seating System manufactured by LYX furniture achieved innovation through using the product's form as its main lever (Figure 1). This product offers an unusual seating system by using two parallel tubes

to achieve a high aesthetic content.

The lever Technology provides an opportunity to apply technology in a new or innovative way by deploying established or emergent but underutilized technologies. An example of this is the Pluma gas cylinder which won the Reddot award in 2006 (Figure 1). The appearance of the cylinder closely resembles traditional gas cylinders, but it provides advanced strength and safety due to the new combination of materials.

Mode of Use is a lever used to create a new way of using a product by exploring its function and use. Mode of Use as a starting point for design-driven innovation is exemplified in the kitchen funnel of Normann Copenhagen (Figure 1). Beyond the essential functionality of a funnel, this collapsible kitchen utility provides far easier storage. The product has also won several design awards such as Reddot, the Good design award, and the Design plus award.

These examples show that design innovation has various aspects, and each lever may facilitate different aspects of innovation in different ways. By investigating innovative products in parallel with the concept of innovation itself, previous research has contributed to a definition of design innovation and the ways in which it may be achieved.

However, previous work has often explored design innovation from the perspective of people who try to achieve it, especially in the fields of economics, marketing, and design (Mutlu et al, 2003). There have been fewer attempts to investigate how users actually perceive innovation and innovative products. If there are perceptual differences between those responsible for the design of innovative products and the end user, understanding these differences will be of use to designers in the aims of developing more innovative products.

This study aims to investigate how people perceive innovation, and how perceptions may differ dependent upon design background and the kind of product or product category being perceived. Finally, the study explores the relationship perceived innovativeness has to desirability.

With these research aims in mind, the following three hypotheses are proposed:

1. Designers and non-designers have different perception of design innovativeness.
2. The holistic innovativeness of a product is related to three types of innovativeness: Form, Technology and Mode of Use.
3. The desirability of a product related to perceptions of its innovative qualities.

In order to test these three hypotheses, products were chosen as examples of design-driven innovation and surveys were performed to gather data on attitudes towards and perceptions of design driven innovations.

2. Methods

2.1. Participants

Forty undergraduate students were recruited from the researchers' institution. Half of the sample were industrial design majors, the other half were taken from both engineering and management fields. The following criteria were used in deciding the sample's attributes:

- Subjects classified as 'Designers' were unrolled in a full time undergraduate degree in Industrial Design with at least two years of completed studies.
- Subjects classified as 'Non-Designers' were unrolled on a non-design degree course with no experience of design based teaching or related courses.

Although the age range of the sample group was quite narrow, psychological research has indicated that openness to experience shows a flat pattern from emerging adulthood through middle age (Christopher et al, 2011). As such, the research indicates age may be of limited

influence upon perceptions of innovation. Moreover, while admitting the probable influence of generational perceptions of innovation, this study focuses upon educational experiences as an influence upon perceptions of design innovation.

2.2. Products

In order to compile a list of products representative of design-driven innovation, winners of the 2012 Reddot product design awards were reviewed. As indicated by Zec (2007) the Reddot awards are among the longest running of design awards (Sung et al, 2009). Moreover, in the few studies conducted to explore the benefits of design awards, Reddot is described as a leading international competition with one of the largest application rates (Sung 2007, Sung et al 2009, Zec 2007). Therefore, Reddot design award winners have been judged by an expert panel of judges to be innovative and to embody good design.

In 2012, a total of sixty products from eighteen categories won the Reddot best of the best prize (Online exhibition: Best of the best, http://red-dot.de/pd/). Among eighteen categories, eleven were selected according to the following criteria based upon the product design categories suggested by Rogers & Milton (2011).

- Highly related to industrial product - not 2D design products or interior design
- Familiar to the general public - do not employ knowledge from specific fields

From each category, the first listed products presented in the Reddot awardees online exhibition were chosen (http://red-dot.de/pd/). Table 1 presents the name and an image of each selected product.

Table 1 Selected Products as examples of design–driven innovation

iPad smart cover	Mindport®	Shallow swing	Basic Line 3520
Firephant	Blow	Smart ebike	Sarah Wiener
Hultafors 209	Econe	Axor Citterio M	

2.3. Experiment Design

During the session, information relating to each product was displayed through a monitor. The product description page consisted of product name, product category, short descriptions in both Korean and English, and 2~3 representative images presented to the subjects through a large display monitor. In order to minimize the effect of order, four different order types were selected from a standard Latin square and utilized. Each order type was assigned to ten participants randomly. Figure 2 shows an example product description page for the Apple iPad Smart Cover design.

The product name was given in bold letters at the top left of each slide. This was followed by the category title, as indicated on the Reddot online exhibition pages (op cit.). Below this a short descriptor was enclosed within a light grey box. Finally, representative images of the product were presented (Figure 2).

iPad Smart Cover
Electronic device accessories

슬림한 아이패드의 디자인을 헤치지 않으면서, 아이패드의 기능과 완벽히 호환되는 아이패드 커버.
커버를 여는 동작을 통해 아이패드의 화면을 키거나 끌 수 있다.

The Smart Cover was conceived to protect the iPad 2 against the challenges of daily use. It fulfils this function through a design of friendly appearance paired with stunning functionality. Extending on the design idiom of the iPad, the Smart Cover too maintains a thin and lightweight profile. It protects the screen without covering the robust aluminium rear side. The mechanism, with which the Smart Cover automatically "wakes" the iPad when it is opened and puts it to sleep when it is closed, is impressive.

Figure 2 An example of product description pages

2.4. Experiment Procedure

Each experiment was composed of two parts. In the first part, the innovativeness of each product was evaluated in order to investigate the possibility of perceptual differences between design students and non-design students. In the second, the desirability of each product was assessed to investigate the relationship between innovativeness and desirability.

(1) Part I

According to the innovation model suggested by Rampino (2011), design-driven innovations have three possible levers. Based upon Rampino's (ibid) innovation model, this research utilizes these three conceptual innovation levers - Form, Technology, and Mode of Use.

As discussed above, innovativeness of Form is achieved through the designer's attention to and use of the Form lever. This then results in an innovation of aesthetics, which is related to emotional responses and product semantics (Norman, 2007). Innovativeness of Technology is the degree of technological innovation which may then provide advanced and innovative functionality (Verganti, 2009). By engaging the technology lever the designer employs emergent or established technologies in new and creative ways, resulting in technological innovation. Finally,

Rampino's (op cit.), Mode of Use lever relates to innovation in the way that a product is designed to function and the ways in which people may use it.

These three levers may act independently or mutually to inform design-driven innovations. As such, the holistic innovativeness of a product may be described as the comprehensive degree of innovation that a product may possess as a result of the interaction between these three levers.

Based upon Rampino's (op cit) innovation levers, four statements were included in the survey to assess the participants' perceptions of: innovativeness of Form, Technology, and Mode of Use. A forth statement was included to measure perceptions of the holistic innovative of each product (Figure 3).
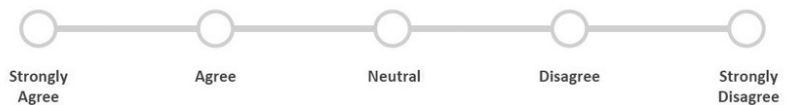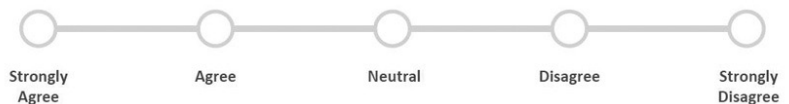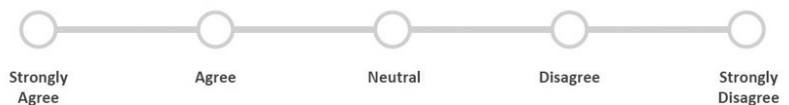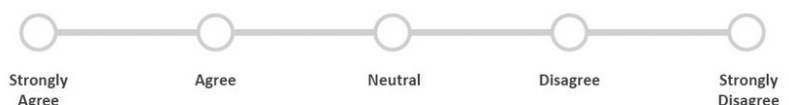

Figure 3 Questionnaire of Part I.

For completion of part one of the survey, participants were given a time limit of 25 minutes, where subjects were allowed to freely surf product description pages and change their answers as required. Through this approach to participant engagement with the examples of innovate products, subjects were provided with the opportunity to become accustomed to the concept of innovation and so standardize their own

judgment criteria.

(2) Part II

Part II of the survey was conducted sequentially after the completion of Part I. Participants finished Part I using the same product description pages. For Part II, participants again accessed the example innovative products. However, this time they were asked to assess the desirability of each product using 5-point Likert scale (Figure 4). Because desirability is a subjective concept, participants were asked to answer each question one by one in an attempt to capture their intuitive feelings. Participants were again given a time limit of 25 minutes to complete part II.
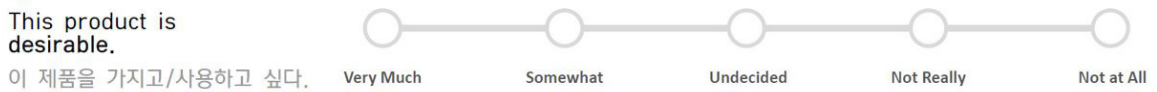
This product is
desirable.
이 제품을 가지고/사용하고 싶다.

| Very Much | Somewhat | Undecided | Not Really | Not at All |

Figure 4 Question of Part II

3. Results and Discussion

3.1. Educational differences

A mixed ANOVA was conducted which examined the effect of educational background on the participants perceptions of innovativeness, with a repeated-measure variable of the eleven different products and a between-group variable of the academic major of the participants.

A significant main effect of major on the participants perception of holistic innovativeness was found: $F(1,38) = 4.372$, $p < .05$. This result supports hypothesis 1 which states perceptual differences towards innovativeness between designers and non-designers.

As shown in the Figure 5, design students evaluated a lower holistic innovativeness of products compared to the non-designs. It may be that they perceive the product examples as less novel or innovative because

they are more familiar with the products which receive design awards compared to the non-designs. That is, their exposure to design and their design education has implications for their own perceptions of product innovation.
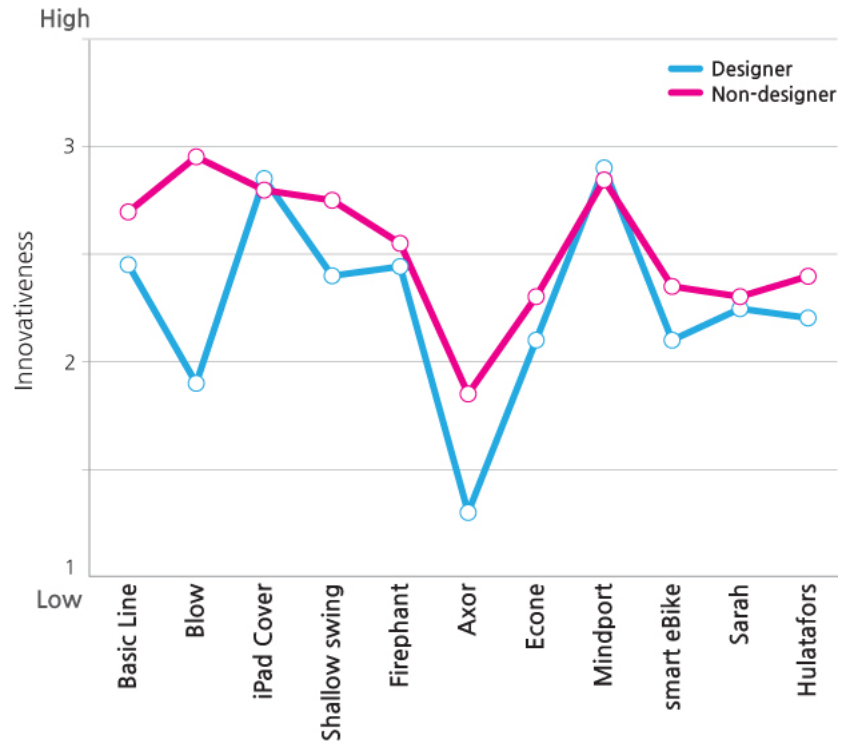

Figure 5 Influence of major on ratings of holistic innovativeness

In the cases of innovativeness of Form and Technology, ratings from design students and non-design students were statistically no different. This suggests that innovativeness of Form and Technology are perceived the same in general regardless of educational background.

In contrast, there was a significant interaction effect between education and types of product on ratings of innovativeness of Mode of Use, $F (10, 380) = 2.797$, $p < .01$. This indicates that certain products were perceived as more innovative in terms of Mode of Use by design students than non-design students. Figure 6 is an interaction graph which shows the different trends of perception using individual lines for each product.
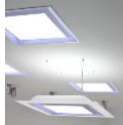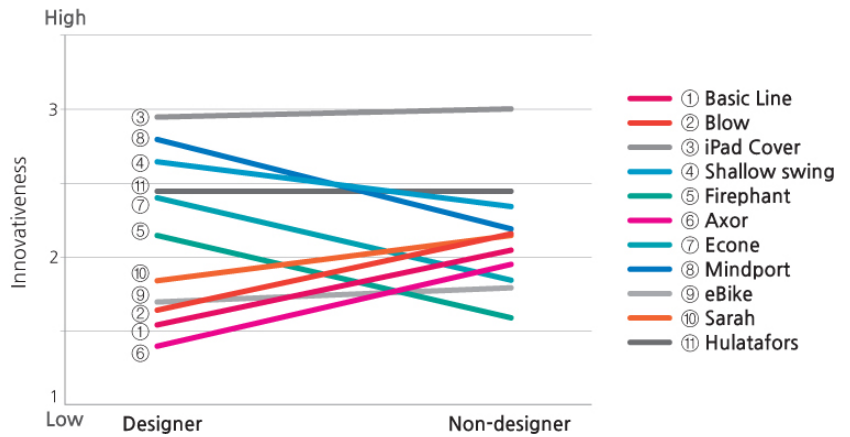
Figure 6 Interaction graph of innovativeness of Mode of Use

Looking at the slope of each line representing the 11 products deployed in the survey, three categories of products are identified. Four products with a downward slope; Shallow swing, Firephant, Econe, and Mindport receive a higher grade for innovativeness of Mode of Use by design students than non-design students. The four red lines with upward slopes indicate products that non-design students perceived as more innovation in terms of Mode of Use than design students; Basic Line, Blow, Axor, and Sarah. The three lines with little inclination suggest these three products are not differently perceived by the different majors. Table 2 illustrates this categorization of the 11 products.

Table 2 Category based on perception difference of Mode of Use

Characteristics	Products			
Design students rated higher innovativeness of Mode of Use.	Swing	Firephant	Econe	Mindport
Non−design students rated higher innovativeness of Mode of Use.	BasicLine	Blow	Axor	Sarah W.
No significant difference between design students and non−design students.	iPad Cover	Smart eBike	Hultafors	

It is interesting to contrast this result with that of holistic innovativeness. Although design students gave lower ratings than non-design students in terms of perceiving the holistic innovativeness of products regardless of product type, they gave higher ratings for the innovativeness of Mode of Use for certain products. This may indicate that there are preferred types of products which exhibit innovation of Mode of Use which designers are more sensitive towards compared to non-designers.

The data gathered in this research does not suggest possible reasons for perceptual differences, the implicit nature of these differences could be investigated in further studies. However, these results indicate Mode of Use as more sensitive to the influence of design education compared to the other levers. In addition, the innovativeness of Mode of Use may affect the rating of holistic innovativeness and so contribute to perceptual differences between the two groups.

3.2. The relationship between holistic innovativeness and three levers

A Pearson product-moment correlation was run to explore the relationship between holistic innovativeness and the three levers of innovativeness: Form, Technology and Mode of Use. Hypothesis 2 assumed that each product has a main lever which affects perceptions of the product's holistic innovativeness. However, Table 3 shows that most of the products have significant correlations with all three levers. Therefore, in contradiction to hypothesis 2, this result suggests products that are perceived as holistically innovative are also perceived to embody all three innovation levers in more or less equal measure.

In particular, the form factor of every product showed statistically significant correlation with holistic innovativeness (all $ps < .01$). In addition, the correlation coefficient of Form is higher than that of Technology or Mode of Use, total $r = +.54$, $p < .01$. This result suggests that the form of a product has a greater influence upon perceptions of holistic innovativeness regardless of the nature of the product being perceived.

In the case of Technology and Mode of Use, two products showed

no significant correlation with holistic innovativeness. This may imply the possible difference across product categories. However, to specify the different perceptions of holistic innovation and its relationship with product categories is beyond the scope of this study. Instead these results indicate an overarching relationship between holistic innovativeness and innovativeness of Technology which appears to be strong, total $r = +.50$, $p < .01$, as was innovativeness of Mode of Use, total $r = +.52$, $p < .01$. These findings suggest perceptions of holistic innovative are most lightly to be present when the product is also described as an innovation in both Technology and Mode of Use.

Table 3 Pearson correlation coefficient between holistic innovativeness and three levers

Holistic innovativeness of	Innovativeness of Form	Innovativeness of Technology	Innovativeness of Mode of Use
BasicLine	+.50**	+.24	+.23
Blow	+.48**	+.57**	+.52**
iPad cover	+.45**	+.45**	+.57**
Swing	+.43**	+.36*	+.43**
Firelephant	+.66**	+.62**	+.40*
Axor	+.74**	+.67**	+.54**
Econe	+.41**	+.30	+.54**
Mindport	+.51**	+.48**	+.45**
Smart ebike	+.57**	+.56**	+.27
Sarah	+.61**	+.65**	+.60**
Hultafor	+.62**	+.56**	+.61**
Total	+.54**	+.50**	+.52**

n = 40
 * p < .05, 2−tailed
** p < .01, 2−tailed

3.3. The relationship between desirability and perceived innovativeness

In order to analyze the relationship between desirability and the four types of innovativeness, a Pearson product-moment correlation was run. The data satisfied no violation of normality and linearity in performing the correlation analysis. As shown in Table 4, desirability was significantly

correlated with four types of innovativeness regardless of the participants' educational background (all ps ‹ .001). This result suggests that the perceived level of innovativeness has a relationship with desirability. Hence, hypothesis 3 was accepted which states that desirability is related to the innovativeness of the product.

Although the four different innovativeness measures have a significant relationship with desirability, it does not mean that these relationships are absolute, but graded. The strength of a relationship is determined by the absolute value of correlation coefficient r.

Table 4 Pearson correlation coefficient between desirability and four types of innovativeness

Desirability of	Holistic innovativeness	Innovativeness of		
		Form	Technology	Mode of Use
Design students	+.52**	+.41**	+.22**	+.45**
Non-design students	+.46**	+.23**	+.26**	+.27**
Total	+.48**	+.32**	+.24**	+.36**

Total n = 40
** p ‹ .001, 2-tailed

According to Salkind & Rainwater (2000), the variables have a weak positive relationship if the correlation coefficient r is between .20 to .39 and have a moderately strong relationship if it is between .40 to .59. As such in Table 4 the values of moderate relationship are given in bold.

In the case of the design students, only the innovativeness of Technology showed a weak relationship with desirability. In contrast, non-designer students indicated a weak relationship between desirability and all three levers of innovativeness: Form, Technology, and Mode of Use. This result suggests that the innovativeness of Technology has less of an impact upon perceptions of product desirability regardless of major. This tendency is much stronger among design students, who showed higher coefficient r values in innovativeness of Form and Mode of Use compared to the non-deign students. The higher r values indicate that perceived levels of innovativeness are also reflections of perceptions towards desirability. That is, it seems that design students recognize Form

and Mode of Use as innovative product characteristics more distinctively than non-design students and utilize this awareness as important criteria to decide desirability.

However, in the perceptions of the non-design students the relationship between desirability and certain aspects of a product's innovativeness are far weaker. Contrary to design students, it appears that non-design students rarely consider certain features; Form, Technology, Mode of Use, when assessing product desirability. Instead of considering certain product features, desirability seems to be more closely related to holistic innovativeness.

This result implies the importance of the balanced use of the innovation levers proposed by Rampino (2011) in the development of products to increase desirability for people with limited exposure to or awareness of good design, as expressed by the Reddot winners. That is, if a product's design relies, for desirability, too heavily upon one innovation lever, it may not be enough to trigger desirability as experienced by the intended user.

4. Conclusion

This study has explored perceptual differences and relationships between holistic innovativeness and three innovation concepts: Form, Technology and Mode of Use as proposed by Rampino (2001). The possible association between perceived innovativeness and desirability were also investigated.

Results indicate perceptual differences towards holistic innovativeness between design students and non-design students. The two samples also rated the innovativeness of Mode of Use differently with interaction effects of major and types of product. These findings suggest differences in back-ground and education have a significant influence on the evaluation of innovativeness in product design. In the comparison

of design and non-design students in terms of their perceptions of innovation, there is no doubt many more factors affect perceptions of design innovation. This investigation provides a starting point for the exploration of these differences and their influence upon perceptions of innovation in future studies.

Contrary to our hypothesis, most products showed similar degrees of correlation between holistic innovativeness and the three innovation levers. This indicates that the perceived innovativeness of a product embraces all three features of Form, Technology, and Mode of Use. Among these three features, Form factor had the strongest relationship with holistic innovativeness. It implies the possible role of Form factor in communicating innovation. Further studies are now required to continue to develop an understanding of how innovation of form relates to perceptions of product innovativeness.

Both designs and non-designs indicated the ways in which they relate holistic innovativeness with desirability. It seems that perceived levels of holistic innovativeness can affect the desirability of certain products. In contrast, Technological innovation had a significantly weaker relationship to desirability. This result suggests that people may not desire a product although they perceive it as innovative in terms of technology. In this regard, this study starts to explore and make more explicit the relationship between desirability and innovation. Further studies may provide insight into the implications this has for the market success of design innovations.

Although this research has begun to explore and make more explicit our perceptions of product innovation, it also indicates the rich complexity of the concept. Research related to design innovation has started to develop our understanding of the relationship between design innovation and its acceptance in the real world by the end user. In this regard, understanding perceptions of innovation may provide designers with opportunities to consider the ways in which their innovative products may be perceived and accepted as such by others. In doing, this will then act as a bridge between research to explore the concept of innovation and its pragmatic application in support of design practice.

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