

Influence of Mindset on Design Performance

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Thinking style and personality traits are considered influential on a number of behaviors and qualities. Previously, a concept of mindset has been defined as a merger of personality and thinking style, hence acknowledging that such intrinsic properties of oneself play a different role from extrinsic properties they influence. Such extrinsic variables studied, involve creativity and design performance. For purposes of current position, design performance is considered, in relation to the mindset profile. However, a useful framework for such study is provided by the reflexive mindset relationship first, connecting thinking style and personality. In a study conducted at Shanghai Jiao Tong University in China, students from two classes (design class open to student body at large, and engineering class open to first year engineering students only) were asked to complete questionnaires and a mini-design project, responses to which helped quantify their mindset and design skills. Findings include superior rationality and extraversion in engineers, and their inferior emotional stability, compared to the neutral sample. Results on extraversion, as well as some relationships, were unique, and call for a confirmatory study.

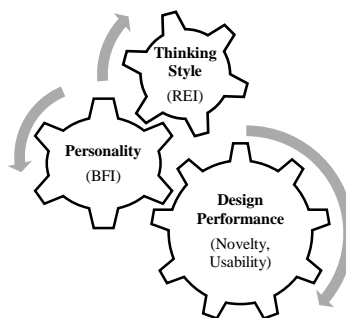


Fig. 1 A proposed framework on the effects of thinking style and personality on design performance

1. Design Performance

Students' design abilities were assessed from results of a small, individual 2-hour design project. They were required to hand in their final conceptual design in a paper based, design-log format. Their work addressed the following design problem:

You're creating a new game with your fellow engineering students. Your goal is to launch a ping-pong ball at a bull's-eye target, which lies horizontally on the ground. As part of the game, you are to design a ball launcher: a device that can lift up the ball, and deliver it at the target. The most accurate launch wins. Initially, you are located 5 meters away from the center of the target. (As you only aim for the center of the target, you do not need to know its diameter, just location from the center.) Your entire device is not to exceed 1 m x 1 m x 1 m in size (length, width, and height). You are not allowed to throw the ping-pong ball at the target. You are, however, encouraged to pursue novel or unusual solutions, while holding precise delivery aim imperative. (Atman, Cardella, Turns, & Adams, 2005)

Furthermore, the work completed by these students was then assessed for two different quantities: novelty and usability. Novelty N , which aims to depict the unusual or unexpected in a design, was used as one assessment variable (Shah J. M., 2012). The novelty, defined in equation (1), is found relying on functions and sub-scores. Main functions were identified as *launch*, $f_1 = 0.5$, *aim for target*, $f_2 = 0.2$, and *ball feeding*, $f_3 = 0.1$, with quantities representing the weights assigned based on their individual importance and number of appearances. Sub-scores, defined in equation (2), were introduced from total number of ideas generated, T , functions f , and count of solutions C . Each subscript j represents an identifier.

$$N = \sum_{j=1}^n f_j S_j \quad (1) \qquad S_j = 10 \times \frac{T_j - C_j}{T_j} \quad (2)$$

Usability was assessed through the form of an expert panel, consisting of a USC professor, four doctoral students, and seven master's students. Each expert assigned a score ranging 1-5 for each design's usability, i.e. the design's address of performance requirements. (Chulisp & Jin, 2006; Shah, Vargas-Hernandez, & Smith, 2003)

These scores provided certain insights into similarities and differences among designs of engineering students and non-engineering students. Table 1 depicts these results. Considering only design variables, it can be noted that the engineering students were merely 1% more novel than the non-engineering students, with both scores being approximately 8.2, for the novelty range of 6.6-9.5 for both non-engineers and engineers. The engineering students also had the lead in usability of their designs, albeit again by a small percentage of 4%, with the average usability score of non-engineers being 3.1, and engineers 3.2, on a 1-5 scale. The scores for non-engineers ranged from the lowest score of 1 to the highest score of 5, generating the 3.1 average through a distribution. Conversely, the scores for engineers were binary, generating either the score of 3 or 4, and as such yielding a similar average of 3.2. This, perhaps, is the most interesting comparison within the design analysis, as it depicts the lack of variety and distribution, as

well as the lack of a “perfect” design among the engineering students. Saying that engineering usability was assessed as mediocre to good, but never excellent, easily leads into connections between design performance and thinking styles or personality traits. As it will soon be clear, engineers consistently offer steadier results than non-engineers, leading to a few speculations.

2. Mindset and Design Performance of Engineers and Non-Engineers

Within this study, mindset is already defined as the overarching concept adjoining thinking styles and personality traits (Milojevic, Ghirardello, Zhang, & Jin, 2016). In this study, *thinking style* is assumed to be binary – either rational or experiential, per the scale used to evaluate it (the Rational-Experiential Inventory, REI) (Epstein S. , 2003). Relying on cognitive-experiential self-theory (CEST), for purposes of this study and Milojevic at al. study, CEST and REI frame two systems – rational and experiential, used as variables of mindset. Relying on them, careful consideration is given to finding the difference in rationality or intuition among engineers and non-engineers studied. *Personality* is, additionally, rooted in five variable traits: Extraversion, Agreeableness, Conscientiousness, Emotional Stability, and Openness, proposed by the Big Five Inventory, BFI that studies the big five dimensions of personality (Goldberg, 1992). Together, the seven quantities shape the mindset model, which consists of the two “drive gears” in Figure 1, influencing one’s design performance. When finding quantitative scores for variables, first hypothesis of the study was formed:

H1: Engineering group outperforms the Non-engineering Design group in Rationality (REI), Agreeableness, Conscientiousness, Emotional Stability (BFI), and Usability (Design). For Experientiality (REI), Extraversion, Openness (BFI), and Novelty (Design), the Non-engineering Design group performs higher.

Table 1 provides information required for comparison between quantitative mindset and design performance scores, where the *% Difference* quantity favors engineers, such that if positive, the engineers are scoring better than the non-engineers. As mindset variables quantify on the 1-5 scale, they are easily compared among themselves. The engineering student sample exhibits 10% more rationality than the mixed, non-engineering sample, and exhibits approximately equal levels of intuition. Personality-wise, engineering students lead with higher scores across board, except in emotional stability, which they severely lack compared to the non-engineers, with engineers being found at 12% more neurotic (i.e. less emotionally stable) than the non-engineers. The engineers score with significant superiority on extraversion and conscientiousness, with 13% and 9% better scores than the non-engineers, respectively. Engineers also somewhat outperform non-engineers in traits of agreeableness and openness, with the 6% and 4% higher scores. These results offer grounds for analysis of correlations depicted in Figure 2, upon proposing analysis of the performance comparison from Table 1.

It is important to observe that the engineering sample exhibits superior or equivalent traits and results when compared to the non-engineering sample. In only one case does the non-engineering sample outperform the engineering one, and it is only in

the case of emotional stability decrease among engineers, demonstrating their considerably poor performance on this personality scale. On average, engineers exhibit considerably superior traits of rationality, extraversion, and conscientiousness, and moderately superior traits of experientiality, agreeableness, openness, and design novelty and usability scores. This can be described as curious behavior, considering that common opinions prevail about introversion in engineers, as well as calm, collected behavior, which should lead to emotional stability, while engineers are also assumed to lack openness. Observing how all of these assumptions are disarmed, this finding can be considered fairly unique. Furthermore, if engineers are seldom expected to be creative, but always aware of functionality of their products, then it is curious to note the close similarity in design performance of both groups. What can be deduced from findings is that engineers and non-engineers alike perform practically equivalently in both measures of design.

Table 1 Mindset and Design Variable Scores

<i>Scale</i>	<i>Variable</i>	<i>Engineering Students</i>	<i>Non-engineering Design Students</i>	<i>% Difference</i>
<i>REI</i>	Rationality	3.78	3.43	10%
	Intuition	3.15	3.12	1%
<i>BFI</i>	Extraversion	3.24	2.87	13%
	Agreeableness	3.98	3.76	6%
	Conscientiousness	3.51	3.22	9%
	Emotional Stability	2.68	3.05	-12%
	Openness	3.51	3.39	4%
<i>Design</i>	Novelty	8.22	8.16	1%
	Usability	3.17	3.06	4%

3. Relationships within Mindset and Design Frameworks

From the literature review and knowledge of psychology, as well as our own perceptions of rational or experiential, engineering or non-engineering focused subjects, two additional study hypotheses were formed for the reflexive mindset study and the mindset-design study, respectively:

H2: Among the five personality (BFI) variables, *Conscientiousness*, *Agreeableness*, *Emotional Stability* relate positively to *rationality* (REI), while *Extraversion* and *Openness* relate positively to *experientiality* (REI). Engineers are dominantly rational.

H3: In engineers, the rationality and design usability are related. In non-engineers, the experientiality and design novelty are related.

3.1. Reflexive Mindset Relationship

The reflexive mindset relationship specifically aims to frame how thinking styles relate to personality traits. Complete studies of such connections were previously performed in detail (Milojevic, Ghirardello, Zhang, & Jin, 2016; Wittman, 2009). Here, the goal is to explain how higher or lower correlations among their individual variables may generate relevant information. The comments pertain to the Mindset Profile section in Milojevic et

al paper (Figure 2). In this case, the observations from REI-BFI relationship agree with the study by Witteman et al. Within the personality frame, a few interesting findings should be listed.

For one, *extraversion* can be analyzed. While rational and experiential engineers maintained steady extraversion levels, the general design group showed a counter-intuitive behavior with those of higher experientiality exhibiting higher introversion, and those of higher rationality exhibiting higher extraversion. All rational students were considerably agreeable and conscientious, while the experientiality in engineers adversely affected both their *agreeableness and conscientiousness*. The rational group, regardless of field, was highly neurotic, particularly the engineers, while in experiential engineers, the *emotional stability* was, on the contrary, surprisingly good. The general design group was mildly neurotic regardless of thinking style. Finally, *openness* has correlated well with thinking style in both groups, but it was found that rational engineers and experiential non-engineers emerged as the most open.

3.2. Mindset-Design Performance Relationship

The first set of correlations analyzed involves the rational-experiential scales (thinking style) correlated with novelty and usability (design performance). From scores, it is noted that the engineering sample is considerably more rational, while intuition is equivalent in both samples. Here, in Figure 2, complete analysis can be performed on correlating the two variables of design performance with each variable of mindset, stemming from REI and BFI scales. It is already known what the actual scores reveal, yet correlations offer a unique insight into the results, proposing new ideas.

For one, in the domain of thinking style, it appears that *fortune favors the rational*. Rationality is correlated to good design performance in every case aside from usability in the engineering sample. Unlike rationality, intuition seems to correlate with poor design performance in all cases, except the intuitive design sample, in which it correlates to very good usability. This ought to demonstrate that *rational people are superior designers*, with only rational engineers finding usability a challenging requirement. Additionally, the correlation proposes that intuition in these samples has an adverse effect on all groups except the experiential students from the design group, which exhibit superior skills in addressing usability.

Personality domain offers further insight, but provides more agreements across each personality dimension. In the case of extraversion, it appears to correlate negatively to performance of the design class, and positively to that of the engineering class, for both design variables, leading to conclusion that the difference in student profiles does not play a significant role. In case of agreeableness, novelty and usability are non-synched, leading to conclusion that the more agreeable students are more novel, and less agreeable students focus better on usability, again without much influence of their chosen field of study. The more conscientious the engineers, the greater novelty they'll produce, and the more conscientious non-engineers, the greater the usability. Needless note emotional stability is a difficult variable in this study. Hence, it only offers one positive correlation – the more stable the design class students, the greater the usability. In each other case, the correlation of emotional stability to design performance is negative, leading to the idea that good designers often have neurotic tendencies, regardless of their

educational background. Finally, the more open the engineering students, the greater the novelty of their designs, while the more open the non-engineers, the greater the usability of their product.

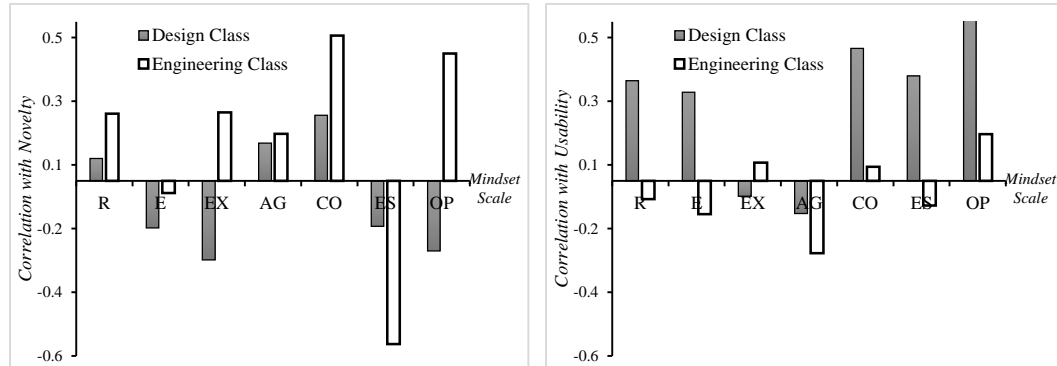


Fig. 2 Correlations between variables of REI/BFI (comprising Mindset Scale) and Novelty/Usability (comprising Design Performance), where Novelty assesses the innovativeness of design, and Usability its likelihood of successful implementation.

4. Future Work

The findings of this preliminary study intrigue, to say the least. The hypothesized and theoretical expectations were greatly challenged by this study. Yet, the beauty of design creativity research, among many, is its flexibility. By finding that not every hypothesis is supported, new hypotheses are called for, as are new perspectives.

What does it truly mean to find that engineers can be more extraverted than non-engineers, if they are predominantly intuitive thinkers? Doesn't that contradict every last assumption and observation drawn from the engineering classes? Moreover, why are non-engineers more dedicated towards addressing functional usability in design, than engineers themselves? And most importantly, why does fortune favors the rational?

If there was one finding calling for further investigation that would be the finding of much higher success rates and better performance of rational people across all categories of evaluation. In an era encouraging tangibility in education, and praising hands-on experiences, it would appear that thinking styles have a different story to share.

For these, and reasons pertaining to securing validity of findings, an identical study will be conducted on a University of Southern California sample of Mechanical Engineering students enrolled in a senior-level course on Design Methodology. A neutral sample class of non-engineers is currently sought. Once such samples from a different university, different country, and even different linguistic and educational environment, have been studied, our group expects to find either validation or further inspiration for continued search.

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