Building a Social-Cognitive Framework for Design: Personality and Design Self-Efficacy Effects on Pro-Design Behaviors

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Abstract

The purpose of this work is to offer a framework that analogously considers factors significant for engineering design and industrial organization, borrowing from literature in domains of cognition and social theories. We conducted two studies: at Shanghai Jiao Tong University and University of Southern California, that allowed us to investigate personal, environmental, cognitive, and behavioral traits and processes, as affected by design self-efficacy, in engineering designers and non-technical designers in training. Through a social-cognitive framework for design, we explore the kind of influencing that occurs among person, environment, and behavior reciprocally. We found that the rational mode of thinking was particularly highly associated with design self-efficacy, and intuitive mode particularly insufficiently associated with design self-efficacy. Design self-efficacy was further positively associated with big five personality conscientiousness, and highly negatively associated with neuroticism, where some significance is seen in specific correlations with design self-efficacy in personality domains. The comprehensive findings call for a repetition study and further theoretical considerations for findings in the framework's domain.

1 A Social-Cognitive Take on Design Creativity

The previous research of the authors had studied design creativity from a standpoint of idea generation and exploration (e.g., Chulisp and Jin, 2006), creative stimulation (e.g., Jin and Oren, 2010), and collaborative stimulation (Sauder and Jin, 2016), largely focusing on more than one designer. While the research thus far had focused on observing how design thinking and

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operation processes occur and how various patterns of such thinking processes impact design outcomes, little attention was paid to identifying various influencers that contribute to the formation of the designers' thinking and operation behaviors. The larger scope of present research focuses on the designer as an individual, treating their cognition, behavior, environment, competences, motivation, actions taken towards completing design-related tasks, and their own design outcomes, as a system of interest. More specifically, we introduce a concept called *pro-design behavior* to indicate the largely habitual *thinking* and *doing* behaviors that potentially lead to higher design creativity and better design performance. Pro-design behavior involves thinking style, creative behaviors, and design performance, later depicted in Figure 1. A general research question to be addressed is: "*what are important influencers that shape someone's more pro-design behaviors*?"

Limiting the research system of interest steadily to an individual designer, there are fewer ways to conduct research interventions. While one might be able to displace an engineer into a new environment, placing them on, for example, a particularly crafted team of designers would not be an intervention of interest. As such, one of the larger goals of this research is to identify and propose an intervention that would allow for designer's most effective use of their dual process thinking (Epstein, 2003; Stanovich, 2000) behind creative design processes.

Early on, the project began with an outlook on proposing a duality to thinking behind creative engineering design. One way to do so was to rely on Epstein's cognitive-experiential self-theory (Epstein, 2003), which proposes human mind as governed by two modes of processing: (i) rational (need for cognition), and (ii) experiential (faith in intuition). The preliminary results indicated that in order for one to be creative and demonstrate creativity with design outcomes, he or she must be approximately equally rational and experiential in their thinking (Moore et al, 2014). In this case, the research remains within the domain of pure cognition.

In addition to the cognitive-experiential self-theory (Epstein, 2003, Witteman, 2009), which aims to study humans from a spectrum across rational and intuitive thinking, the dual process theory (Stanovich, 2000) closely compares in its division onto implicit and explicit processes, with the classification emerging based on the level of conciousness each process carries (Evans, 2013).

Investigating potentially important influencers requires expanding the scope of study on both mental and social horizons by including more aspects into consideration. Some social and mental aspects could be *personal*, such as gender, height or weight, or personality traits. Others could be *environmental*, such as the country or town one lives in, the type of culture they possess, or the type of space they spend their days in. Lastly, they could be *behavioral* and involve habits or actions.

These three social and mental categories are known as *influencers* in studies of social, social-cognitive, and social learning theories (Bandura, 1977, 2001, 2005). Within the influencers that pertain to design creativity, some useful allocations involve:

1. *Personal* influencers: gender, personality
2. *Environmental* influencers: country of residence, professional and academic culture
3. *Behavioral* influencers: thinking styles, behavioral creativity, design performance.

While the three categories of influencers have mutual effects among themselves, the central variable that affects all three, and being affected by them, is *self-efficacy*, defined as "the belief that one can master a situation and produce positive outcomes" (Bandura, 1999). Considering self-efficacy is not a field-uniform measure, we study the effects of *design self-efficacy* in this particular case (Carberry, 2010). Self-efficacy scales for many different processes have either been published and opened up for use, or can be self-made (Bandura, 1977). Carberry et al. (2010) relied on a Massachusetts science and technology/ engineering curriculum framework, and identified the eight steps of a design process for design self-efficacy estimate (MA Dept. of Ed., 2001/2006).

2 Model: A Social-Cognitive Framework for Design

Prior research efforts of the authors had generated a design thinking styles framework (Milojevic et al, 2016), demonstrating relationships between *thinking style* (Epstein, 2003; Pacini, 1999) as a class of independent variables, and three other classes of dependent variables: *personality* (Witteman, 2009; Goldberg, 1993), *behavioral creativity* (Silvia, 2012), and *design performance* (Shah, 2012; Kudrowitz, 2010). The framework demonstrated significant and consistent correlation between rational thinking and the creativity class of variables. The design thinking style framework was created in basic terms in order to initiate a study of dual thinking processes for early stage engineering design and further explore the role of *perspective taking* in idea generation in engineering design (Grant et al, 2011; Lamm, 2007). One direction is to study influencers accessible to a designer. Detecting, studying, and analyzing sets of *influencers* (Choi, 2011; Perry-Smith, 2003) accessible to a designer, serve the greater goal of proposing new training methods and supporting tools for engineering designers, aimed to make them think in a manner best suited for their available design task (De Dreu, 2008).

To further explore ways duality of thinking could be built upon towards an engineering design duality of processing, in cognitive or practical domains, the relationship between the designer's performance, e.g., creative (Choi, 2011), or professional (Schaub, 2005), and the designer's social environment should be considered. Thus begins the exploration of various social theories in domains of psychology and organization.

Based in social-theory driven studies of creativity (Schaub, 2005; Choi, 2011), organization (Bechtoldt, 2010), or design (Baird, 2000), the concepts of *motivation* and *self-efficacy* embedded in particular domains (e.g., creative domain, design domain, and learning domain) quickly emerge as the most considered and least defined. Hence, the research briefly abandons its consideration for specific domains, exploring most purely how one learns the social-cognitive rules and adops beliefs about onself.

The process of learning is commonly defined as a change, in cognition, behavior, or competence. This change can be continuous (Shuell, 1986), persisting (Driscoll, 1994), or relatively permanent (Weinstein, 1986), according to different definitions. In this study, we adopt the definition of learning as *relatively permanent change caused by an experience or action*. This change can occur within particular domains of interest, e.g., cognitive, behavioral, and constructivist. Ultimately, one is capable of learning in very many ways. The specific ways of interest are social-cognitive learning, self-regulated learning, and cognitive apprenticeship learning. Each of these learning strategies can be analyzed in social-cognitive theory (SCT) and social-cognitive learning theory (SCLT) terms. The social theories commonly share the triadic reciprocity (Figure 1) in a form similar to the original triad proposed (Bandura, 2005). An example of such related triad is a visual representation of Cognitive Apprenticeship model (Dennen, 2007). The triadic model communicates reflexive affects between *personal*, *environmental*, and *behavioral* factors. When considering the effect of a person on the environment and their behavior, it occurs by understanding and observing their environment, as well as adjusting behavior for that expected to yield a positive outcome.

The process of triadic social-cognitive influencing is closely related to self-regulated learning, self-management, and self-efficacy. Self-regulation involves *self-monitoring*, *self-judgement*, and *self-reaction*. While these concepts won't be integrated in the social-cognitive design framework, they are the drive-concepts that make self-efficacy scoring in the form of a scale accessible (Zimmerman, 1990).

In order to form the model proposed in Figure 1, titled Social-Cognitive Framework for design, proposing the SCT triad with attributes adequately assigned to the three main factor categories, would suffice. However, in order to ensure the model is being understood from its affective standpoint, we rely on the expanded, social-cognitive career theory (SCCT), driving concepts, such as learning experiences, outcome expectations, and actions, while self-efficacy remains present for all social-cognitive domains (Schaub, 2005).

Personal factors are intrinsic to a person within the social-cognitive framework, and divided into *biological* (assigned at birth), *cognitive*, and *affective* (changes in cognition). In this case, the *personal factors* studied will be biological (gender/sex) and cognitive (Big Five Personality). The environmental factors studied are culture (discipline) and country (location). Finally, the behavioral factors studied are Creative Behavior (*biographical creativity*, *behavioral creativity*, and *domain-creativity*), Thinking Style (*rational* and *intuitive*), and Design Performance (*novelty* and *usability*), as indicated in Figure 1.

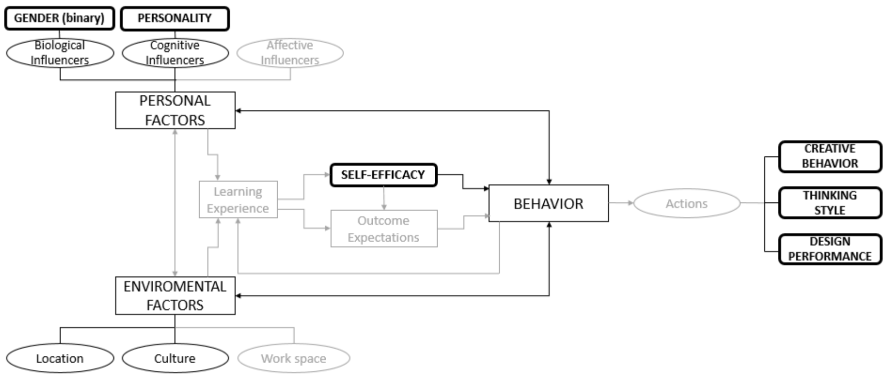

Fig1. Framework for building social-cognitive design perspective, studied partially, with respect to personality as a single personal influencer on design self-efficacy, and behavior per effects of design self-efficacy

3 Methods: Assessing Design Self-Efficacy and its Effects on Pro-Design Behaviors

The proposed framework of social-cognitive framework for design (Figure 1) is an expansive triad of personal, environmental, and behavioral influencers, which constantly drive one-another, drive and are being driven by design self-efficacy, and offer potential for further propositions of categorical and relational development within. Considering it is an early stage emergence from bringing social, learning, career, and cognitive theories into the realm of design in engineering and interdisciplinary domains, the social cognitive framework for design can be unveiled into a more intricate theoretical framework driving a more intricate set of outcomes caused by pro-design behaviors of higher complexity. For purposes of this preliminary study, however, the framework is kept at little to no deviance from the Bandura-proposed social-cognitive triad, with categorical attributes assigned to each influencing category, so as to offer the greatest insight into the social-cognitive effects on engineering design, in domains of design cognition and design outcomes, with a potential for application in industrial organization, methodology creation, and artificial intelligence developments.

The research behind the social-cognitive design framework aims to compare design self-efficacy based on its characterization by sets of influencers assumed as mutually exclusive, and, in this case also binary. For example, the concept of *Gender* is assumed as gender binary, either female or male, contrary to the adopted view that gender identity and expression may transcend the binary biological sex (Diamond, 2002). The other two influencers were named *Country* and *Culture*, and are also proposed as binary, in order to define, respectively, the geographic location of the subjects studied (the United States or China) and the academic culture subjects identify and professionally growing in (Engineering or Non-Engineering).

Following suitable framework developments, the following hypotheses were formed, for purposes of this study.

- **H1:** Design self-efficacy will reflect differences within attributes to SCT triadic model's influencers studied: gender, location, culture, and personality.
- **H2:** High design self-efficacy scores are associated with high intuitive thinking scores.
- **H3:** High design self-efficacy scores are associated with high behavioral creativity scores; high design self-efficacy scores are also associated with high design performance scores.

3.1 Subjects

Total of 60 students, pursuing coursework in engineering, design, or both, participated in the study, from their home universities of the University of Southern California (Los Angeles, USA) and Shanghai Jiao Tong

University (Shanghai, China). The sample gender distribution was 18 female students (30%) to 42 male students (70%). Majority of the sample (75%) was based in China, consisting of 45 students, while the remaining 25% consisted of 15 students based in the United States. All were undergraduate students, distributed across class years: 31 students of the first year (51.7%), 10 students of the second year (16.6%), 3 students of the third year (5%), and the remaining 16 students of the fourth year (26.7%). Majority of the sample identified as an engineering student, 46 out of 60 (77%), and 24 (23%) were pursuing a variety of majors, and referred to as the non-engineering students, in this study. Per location, sample based in China had 33.3% of female and 66.7% of male students, 68.9% of engineering and 31.1% of non-engineering students. The sample based in the U.S. had 20% of female and 80% of male students, and was entirely comprised of students in mechanical and aerospace engineering. The U.S. sample yielded one quarter of the entire sample, while the Chinese sample yielded the remaining three quarters.

3.2 Assessment Procedures

All students were asked to complete the following surveys: rational-experiential inventory (REI), big five personality inventory (BFI), biographical inventory of behavioral creativity (BICB), creative behavior inventory (CBI), and revised creative domain questionnaire (CDQ-R), as well as the design-self-efficacy survey, which were then considered in the context of students' social-cognitive influencers.

Rational-experiential inventory (REI) is a measure of thinking style preferences, for **rational** (need for cognition) or **experiential** (faith in intuition) mode of processing in thinking (Witteman, 2009). *Big Five Personality Inventory (BFI)* is a measure of personality, commonly used in psychological and psychiatric diagnosing of personality disorders, alas also beneficial in merely communicating how a person is, through five specific personality traits being assessed: **extraversion**, **agreeableness**, **conscientiousness**, **neuroticism**, and **openness** (Goldberg, 1993). *Biographical inventory of creative behaviors (BICB)* is a measure of behavioral creativity which considers the number of different habitual, every-day creative activities an individual has engaged in in the last 12 months, and it defines the proposed variable of **biographical creativity** (Silvia, 2012). *Creative behavior inventory (CBI)* is a measure of behavioral creativity which considers the number of times an individual has engaged in a tangible, craft or art-driven creative activity, and it defines the variable of **creative accomplishment** (Silvia, 2012). *Revised Creativity Domain*

Questionnaire (CDQ-R) is a measure of behavioral creativity which considers how one perceives oneself in a variety of areas creativity plays a key role, such as acting, leadership, computer science, or solving personal problems, and it defines the variable of **creative ability** (Silvia, 2012). **Design Self-Efficacy** survey is a self-efficacy measure, as it pertains to design tasks and design skills, as well as confidence one exercises in one's ability to perform highly in the areas asked about (Carberry, 2010).

The non-questionnaire defined variables are those of design assessment, which feature design novelty and design usability. **Design novelty** assesses functional creativity of a design solution, relative to frequency of said function being proposed within the set of design solutions being evaluated (Shah, 2012). **Design usability** is an expert panel-assessed measure of how effectively design addresses user-needs (Kudrowitz, 2010).

Results of surveys are found using standard scoring methods proposed by each survey's author. For surveys that needed to be correlated with one another across many categories, it is important to observe that their most concise form is presented in Table 1, contents of which will be discussed further on.

4 Results: Mutual influences

The quantified variables described in the methods section, and previously studied in contexts of correlation to thinking styles assessed through REI (Milojevic et al., 2016), are now being considered within the expanded, social-cognitive framework proposed in Figure 1. Within this framework, the triadic social-cognitive influencing model, where each relationship of influencers (**person ↔ behavior**, **behavior ↔ environment**, and **person ↔ environment**) is driven by self-efficacy, encompasses elements from the original design thinking styles framework proposed in Figure 1. As such, the analysis of the results is done with respect to **two personal influencers** (**gender** considered ***male*** or ***female*** is a *biological personal influencer*, and **university class standing** considered a ***first-year*** and ***upper-class*** is an *affective personal influencer*) and **two environmental influencers** (**location** considered ***China*** or ***the U.S.*** is a *cultural environmental influencer*, and **field of study** considered as ***engineering*** or ***non-engineering*** is also a cultural environmental influencer) (Bandura, 2005).

In addition to the proposed influencers considered to extend an association to relationships studied among the variables discussed in the methods section, we also consider ***personality***-based variables as attributes of the **personal influencer** category, and ***behavioral creativity*** variables as attributes of the **behavioral influencer category** (Bandura, 1977).

In this study, we had four attributes to the social-cognitive influencing categories. The personal category was attributed *gender* as a biological cognitive influencer, and *personality* as a cognitive personal influencer. The environmental category is attributed *location* and (academic) *culture*. Following are some of the results.

- An average **design self-efficacy** of **73.8** was found for the entire sample, on a scale from 0 to 100.
- Average **personality scores** are, for extraversion **3.12**, for agreeableness **3.82**, for conscientiousness **3.40**, for neuroticism **2.76**, and for openness **3.44**, on a scale of 1 to 5.
- Average **rational mode** score was **3.71**, while the average **intuitive mode** score was **3.09**, on a scale from 1 to 5.
- Average **creativity score** for **biographical creativity** was **0.31** on a scale from 0 to 1, for **creative behaviors** was **1.74** on a scale A-D enumerated 1-4, and for **domain creativity** was **2.98** on a scale from 1 to 5.
- Within the Chinese-based sample that completed a design challenge as well, the measured **design novelty** had the average of **8.21**, with the range from 0 to 10. The average **design usability** was **3.05**, rated on a scale from 1 to 5.

In the analysis of the results, first consideration was given to purely design self-efficacy scores within the context of influencers available, then consideration was given to three factors of behavior: *thinking styles*, *creative behavior,* and *design performance,* as influenced by design self-efficacy, with some context placed upon the previously studied influencers.

Considering the volume of analysis presented here on, it is important to highlight that correlations were calculated between design self-efficacy and each of: *thinking styles*, *behavioral creativity,* and *design performance*, with respect to each suitable set of influencers. Such findings are summarized in Table 1, and reveal many insignificant relationships found. We will use this information to better analyze data in the upcoming sections.

Relying on the information listed in the table, we may state that the following correlation values with respect to design self-efficacy are found significant:

- Rationality (REI) correlation with respect to both genders, Chinese location, engineering field, and personality traits of agreeableness and openness.

- Biographical creativity (BICB) correlation with respect to the engineering field and extraversion.
- Domain creativity (CDQ-R) correlation with respect to the female gender, Chinese location, and non-engineering fields.
- Design novelty (N) correlation with respect to the engineering field and conscientiousness.

Table 1. Table of correlations of listed scores with respect to design self-efficacy score, per each category of influencers within the larger sample. Findings which are significant are marked in bold.

Dep. Variable		**Rat. (REI)**		**Int. (REI)**		**BICB**		**CBI**		**CDQ-R**		**D. Novelty**		**D. Usability**	
Influencer		**Corr.**	**p**	**Corr.**	**p**	**Corr.**	**p**	**Corr.**	**p**	**Corr.**	**p**	**Corr.**	**p**	**Corr.**	**p**
Gender	*Female*	**0.53**	**0.03**	0.27	0.27	0.25	0.32	0.32	0.20	**0.59**	**0.01**	0.10	0.72	0.34	0.21
	Male	**0.46**	**0.00**	0.11	0.51	0.25	0.12	0.15	0.35	0.22	0.16	0.20	0.29	0.13	0.52
Location	*China*	**0.45**	**0.00**	0.02	0.88	0.10	0.50	0.13	0.38	**0.39**	**0.01**				
	US	0.15	0.58	0.16	0.58	0.33	0.23	0.23	0.41	0.18	0.52				
Field	*Engineer*	**0.42**	**0.00**	0.05	0.73	**0.32**	**0.03**	0.22	0.15	0.24	0.11	**0.38**	**0.04**	0.16	0.38
	Non-Engineer	0.39	0.17	0.03	0.92	0.12	0.69	0.12	0.69	**0.55**	**0.04**	0.25	0.39	0.44	0.11
BFI	*Agreeableness*	**0.58**	**0.00**	0.13	0.49	0.13	0.47	0.19	0.29	0.24	0.19	0.02	0.93	0.28	0.17
	Concienciousness	0.63	0.10	0.39	0.34	0.61	0.11	0.55	0.15	0.22	0.59	**0.91**	**0.03**	0.36	0.56
	Extraversion	0.06	0.91	0.45	0.37	**0.82**	**0.04**	0.52	0.29	0.61	0.20	0.43	0.72	0.98	0.12
	Neuroticism	0.42	0.35	0.20	0.67	0.32	0.48	0.37	0.41	0.44	0.33	0.08	0.86	0.35	0.44
	Openness	**0.69**	**0.04**	0.18	0.64	0.03	0.94	0.39	0.30	0.64	0.06	0.48	0.33	0.52	0.29

4.1 Design Self-Efficacy relationship with Personal and Environmental SCT Influencers

Design self-efficacy, with listed associated scores, is:

- *5% higher in* **Men (74.9)**, than women (71.2);
- *14% higher in* **American-based individuals (82.4)**, than Chinese-based ones (70.9);
- *15% higher in* **Engineers (76.5)**, than non-engineers (65.0);
- *Negative 42.6% associated with* **Big Five Neuroticism**
- *Positive 42.4% associated with* **Big Five Conscientiousness**
- *Positive 23% associated with* **Big Five Openness**.
- *Positive 13% associated with* **Big Five Extraversion**.
- *Positive 4.7% associated with* **Big Five Agreeableness**.

What these findings report is that the most impactful influencers under consideration are ***location***, ***discipline***, ***neuroticism (personality)***, and ***conscientiousness (personality)***. Namely, the more favorable location is the U.S., and the more favorable discipline is engineering.

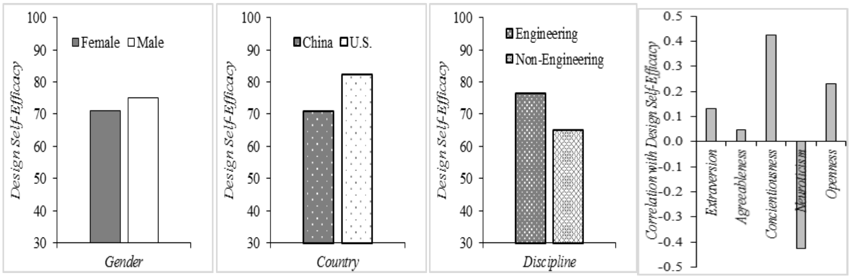

Fig 2. Design Self-Efficacy with respect to personal and environmental influencers; left to right: *gender, binary* (female/male), *country* (China/United States), *discipline* (engineering/non-engineering), and *personality* (extraversion, agreeableness, conscientiousness, neuroticism, and openness)

4.2 Design Self-Efficacy relationship with Intuitive Thinking

Thinking styles were assessed per standard scoring of Rational-Experiential Inventory (REI), generating two separate scores, for rational and intuitive mode. These scores were then analysed in terms of how design self-efficacy scores associate with them, as well as how this association is guided by the available influencers from the previous section.

To address the second hypothesis, we first find the correlations between the overall design self-efficacy and rational mode, as **0.49**, and the correlation between design self-efficacy and intuitive mode as **0.02**.

These relationships, contextualized by the influencers gender, location and discipline in Figure 3 and personality in Figure 4, demonstrate the following observations for rational and intuitive modes.

Rational mode of thinking is associated with design self-efficacy:

- Most positively for subjects located in China
- Least associated for subjects located in the U.S.
- Associated no differently for male or female subjects (association is positive across board)
- Most positively associated for subjects with highest personality scores being conscientious, open, neurotic, or agreeable (in that order)
- Not associated for subjects with highest personality score for extraversion.

Intuitive mode of thinking is associated with design self-efficacy:

- Positively for female subjects

- Negatively associated for male subjects
- Positively for subjects located in the U.S.
- Least associated for subjects located in China
- Associated no differently for engineering or non-engineering disciplines (association is close to none across board)
- Most positively associated for subjects with highest personality score for extraversion
- Not associated for subjects with highest personality score for agreeableness or openness
- Most negatively associated for subjects with highest personality scores for conscientiousness or neuroticism.

The ultimate finding is that the rational mode is better associated with design self-efficacy than is the intuitive mode, which contradicts our hypothesis. Figures 3 and 4 visualize in detail these preliminary findings, yet per Table 1 p-values, any findings regarding the intuitive mode of thinking are insignificant, and rational mode of thinking has a great deal of significant findings, across domains of both genders, Chinese location, engineering field, and personality traits of agreeableness and openness.

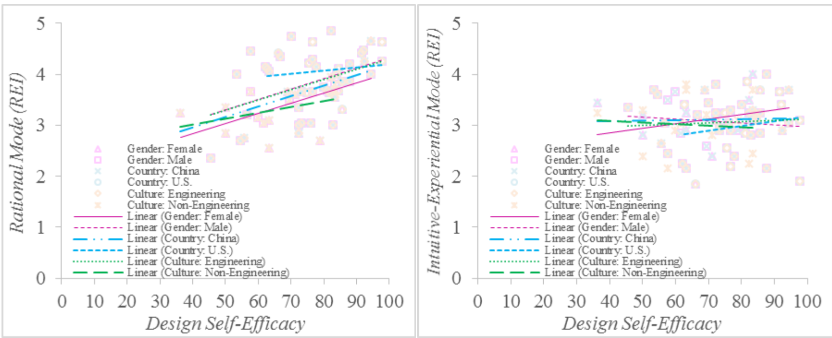

Fig 3. Rational mode of thinking and intuitive mode of thinking with respect to Design Self-Efficacy, contextually studied with respect to the gender, location and discipline of subjects

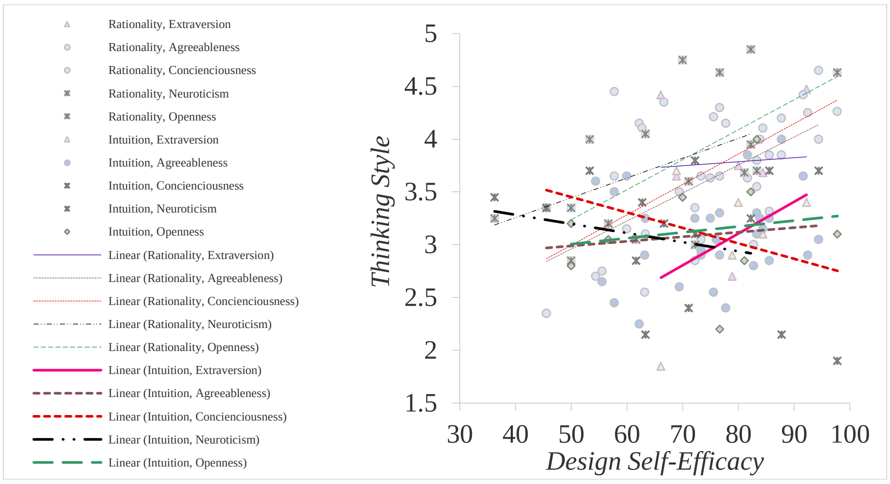

Fig 4. Rational mode of thinking and intuitive mode of thinking with respect to Design Self-Efficacy, contextually studied with respect to big five personality traits: extraversion, agreeableness, conscientiousness, neuroticism, and openness.

4.3 Design Self-Efficacy relationship with Creative Behavior

Creative Behavior was scored using the three designated measures of behavioral creativity:

1) BICB: Biographic Index of Creative Behaviors, to measure biographic creativity
2) CBI: Creative Behavior Inventory, to measure creative behavior
3) CDQ-R: Creative Domains Questionnaire, Revised, to measure domain creativity

To address the third hypothesis, we found the correlations between the overall design self-efficacy and each of these three variables, resulting in correlations of **0.23 for biographic creativity, 0.15 for creative behavior**, and **0.36 for domain creativity**.

In the context of gender, location and discipline – influencers, these variables were studied with respect to design self-efficacy, as depicted in Figure 5.

Biographical Creativity (from BICB) was associated with design self-efficacy:

- Most positively associated for location being the U.S., discipline engineering, and gender male.
- Not associated for subjects based in China.
- Most negatively associated for subjects in non-engineering disciplines.

Creative behavior (from CBI) was associated with design self-efficacy:

- Most positively associated for location being the U.S., discipline being engineering, and gender being female
- Not associated for subjects in non-engineering disciplines

Domain creativity (from CDQ-R) was associated with design self-efficacy:

- Most positively associated for gender being female
- Not associated with non-engineering disciplines.

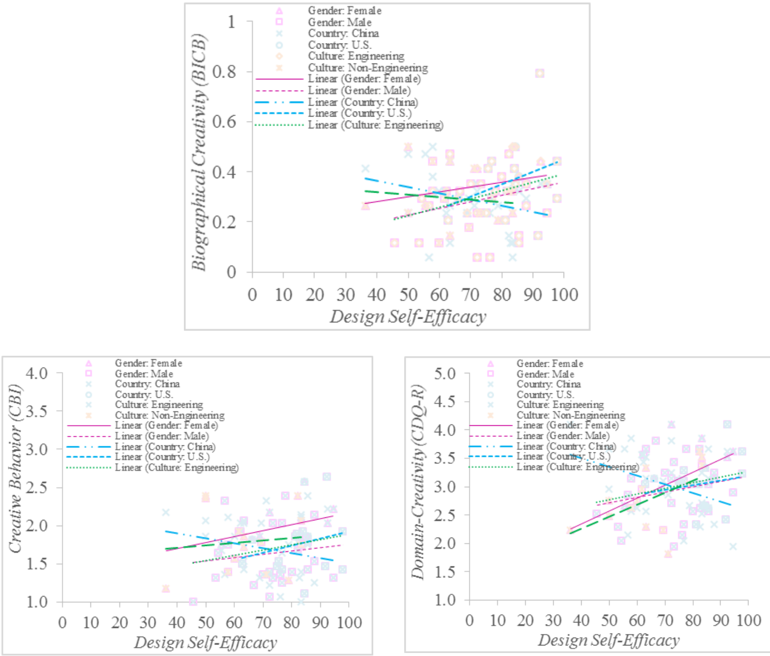

Fig 5. Behavioral creativity scores of BICB, CBI and CDQ-R, studied with respect to design self-efficacy, in the contexts of gender, location, and discipline.

Findings on association of design self-efficacy with behavioral creativity are inviting for further studies in the domain of our proposed hypothesis of their association being high. Figure 5 visualizes the preliminary findings for creative behavior to design self-efficacy relationship. From table 1, we can state that none of CBI related findings are significant, while the BICB findings are significant in domains of the engineering field and extraversion. CDQ-R findings are significant in domains of the female gender, Chinese location, and non-engineering fields.

4.4 Design Self-Efficacy relationship with Design Performance

Design performance was assessed relying on two established variables: design novelty and design usability. These scores had design self-efficacy correlations of **0.11 for design novelty**, and **0.24 for design usability**.

These two variables were then studied in the context of influencers of gender, discipline and personality, as depicted in Figure 6 and Figure 7.

Design novelty was associated with design self-efficacy:

- Most positively associated when discipline is engineering
- Not associated with gender
- Most negatively associated when discipline is non-engineering
- Most positively associated for subjects with highest personality scores in conscientiousness and openness
- Not associated for subjects with highest scores in agreeableness and neuroticism
- Most negatively associated for subjects with the highest personality score in extraversion

Design usability was associated with design self-efficacy:

- Most positively associated with gender being female
- Not associated with discipline
- Not associated with gender being male
- Most positively associated for subjects with highest personality scores of agreeableness, conscientiousness, neuroticism, and openness.
- Most negatively associated for subjects with the highest personality scores of extraversion.

The findings for usability are not significant in Figures 6 and 7, while some of the findings for novelty are, specifically in domains of engineering field and conscientiousness.

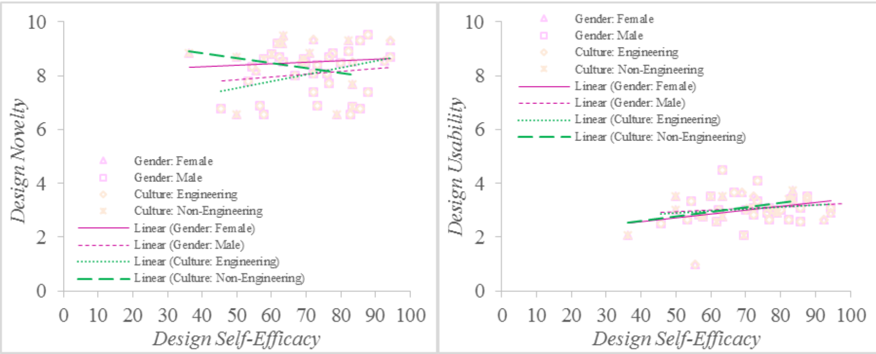

Fig 6. Design novelty and design usability scores, studied with respect to design self-efficacy, in the contexts of gender, location, and discipline.

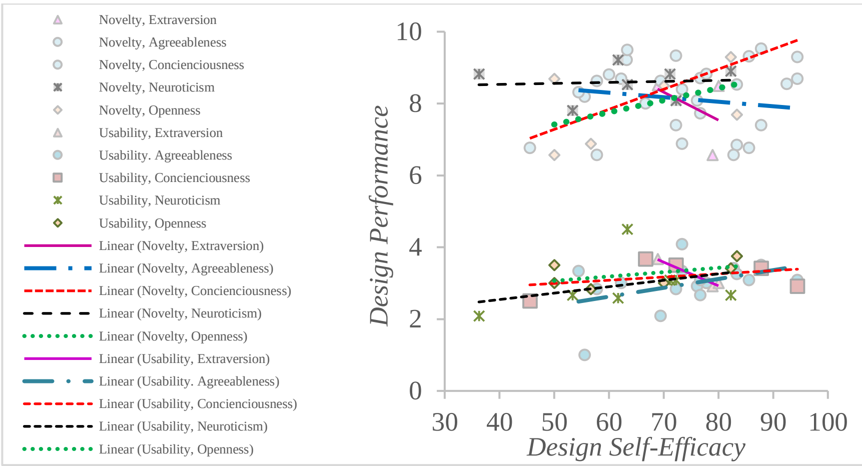

Fig 7. Design novelty and design usability scores, studied with respect to design self-efficacy, in the contexts big five personality traits: extraversion, agreeableness, contentiousness, neuroticism, and openness.

5 Conclusions and Further Recommendations

Bridging design research with social influencing, and thus social-cognitive, and other social theories, while remaining within our original domain of dual process theory and dual process framework for early stage engineering design, has posed a considerable challenge, and is something that few have done before to this extent. While our findings show one disproven hypothesis and two hypotheses that require further considerations, we are of belief that this preliminary work sets ground for further exploration of social and behavioral contexts for design.

We have, in the end, found that the highest correlation with design self-efficacy exists for the rational mode of thinking, at 0.49. No other studied quantity gets even close to correlating this well with design self-efficacy. Rationality also lends itself to the highest number of significant findings among the preliminary ones reported. One way to describe this would be that those who exhibit high rational scores also approach their knowledge acquisition of design steps and methods more rationally, thus being more able to claim that they are highly confident about completing the breakdown of design tasks. Another way to interpret this finding would be that the more rational subjects would have found themselves in more situations where they would need to conduct engineering design, thus building greater expertise and thus greater confidence and motivation for completing the process repeatedly.

To make our second hypothesis strikingly disproven, we should note that out of the entire set of behavioral variables, the correlation found for intuitive thinking mode to design self-efficacy was by far the lowest, and did not carry any significance. The low correlation and very high p-values call for larger sample study or an alternative method for studying intuition.

While the influencing of binary factors like gender, discipline and location was simpler to analyse and deduce findings on, we propose greater exploration of a much challenging influencing process that goes on between big five personality traits and the studied behavioral variables. In our analysis, we could only complete plots of this relationship by selecting the most dominant personality trait (the highest scoring one) and ascribing it as the sole personality influencer for the subject in question. While this offers assistive graphics and a large deal of contextual analysis, one of our next steps includes finding a better method of complete this analysis more wholesomely. Additionally, of the five traits, neuroticism never yields any significance across different correlations studied.

Lastly, we hope to expand our model proposed in Figure 1, in directions of studying creativity from more cognitive or personality-driven standpoints, assessing design through different sets of methods and variables, and finding further organizational influencers that could aid or stifle design processes on individual level. We expect to expand our thinking style variable beyond its current domain, separately study abilities of subjects, and investigate what creative processes assist stylistic use of one's abilities in most successful ways.

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