Exploring the Impact of Cognitive Preferences on Student Receptivity to Design Thinking

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Abstract:

Design thinking is a popular design methodology that encourages iterative problem solving and fosters the creation of human-centered products. The design thinking method, born at the famous product development firm, IDEO, is intentionally loosely structured and fast paced, forcing designers to rapidly prototype and test potential solutions. With its less structured format, design thinking may be more appealing and more readily accepted and adopted by some individuals than others – as anecdotal evidence collected from design classrooms and design thinking workshops seems to indicate. The aim of this study is to determine whether student receptivity to design thinking might be linked to individual cognitive characteristics that reflect innate structural preferences. This research could help educators determine the most appropriate design methodology based on the cognitive preferences of their students, as well as the need to teach coping strategies when students are required to engage in design activities that do not align with their natural cognitive preferences.

Our work presents the results of data gathered during a design thinking workshop in which students engaged in the design thinking process by working through a real world challenge. Student receptivity was evaluated using an ecological mood assessment,[1] and cognitive characteristics were assessed using the KAI, which evaluates the cognitive styles of individuals[2]. A statistically significant relationship was observed between cognitive style and the happiness and excitement scores (two subscales of the ecological momentary mood assessment); we feel that with future experiments, even more correlations might be discovered.

1.0 Introduction

As Dym et al.[3] [p. 1] noted in 2005: "Design is widely considered to be the central or distinguishing activity of engineering." With the world becoming increasingly globally connected, the expectations for engineering graduates to design effective solutions to global problems have never been higher[3, 4, 5]. A wide variety of engineering design methodologies and supporting tools exist, including TRIZ[6, 7], axiomatic design[8], mind-mapping[7,9], and brainstorming[10], all of which help engineers apply their engineering knowledge to the solution of complex, system-level problems and find the optimal solution to meet multiple requirements[11, 12]. Recently, engineering design has shifted to a user-centered focus, incorporating principles from the field of human-computer interactions[13, 14]. Within this shift, design thinking has emerged as a strong methodology that encourages user-centered design and the creation of innovative solutions to complex problems[15].

Despite its current popularity and its effectiveness in many situations, design thinking has not been universally adopted, either by practicing engineers or engineering educators. There may be

a variety of reasons for this lack of universal endorsement, including evidence that design thinking is not equally effective in every situation or for every type of problem[16]. Another possible source of resistance to design thinking could be even more personal – i.e., resistance that stems from individual cognitive differences that lead to reduced receptivity to design thinking principles and methods. In this paper, we explore this possibility through the lens of cognitive style, which has been shown to impact an individual's receptivity to ideas and methods based on the type and amount of structure involved[2]. To the best of our knowledge, this interaction has not been explored in design thinking research.

Cognitive style (also called problem solving style) reflects an individual's preferred approach to managing and seeking to bring about change, including the activities involved in problem solving, decision-making, and creative behavior[17]. In general, these preferences are related to an individual's preference for structure and vary along a continuous spectrum between a strong preference for more structure ("highly adaptive"[2]) and a strong preference for less structure ("highly innovative"[2]), with mild and moderate preferences in between. The application of cognitive style theory in engineering education has grown in recent years, including studies related to concept mapping[18], online learning communities[19], and design ideation[20].

While design thinking has been shown to lead to an increase in creative output in some instances[21, 22, 23], we propose that its loosely structured nature may put a higher cognitive load on individuals with a more adaptive cognitive style as opposed to individuals with a more innovative cognitive style[1]. This increased cognitive load may lead to an increase in coping behavior from adaptive individuals,[2, 24] which can exhaust the cognitive capacity of the individual if maintained for too long[2]; it may also lead to greater resistance (reduced receptivity) to use of the design thinking methodology in general[2, 24]. From an educator's perspective, if design thinking is used in a classroom setting, expecting certain students to perform at a higher coping level than others could negatively impact their overall performance in the design task, rather than enhancing it. Our aim in this research is to gain a better understanding of how students respond to design thinking differently, with a further future aim of helping engineering educators determine the most appropriate and effective design methodology for use with class projects and capstone teams with the individual student in mind.

Specifically, this paper presents a pilot study that explores individual cognitive styles and their relation to student mood levels during an application of the design thinking process. Students were led through the stages of design thinking as they solved a design challenge in a 2-hour workshop setting; both cognitive style and mood were assessed individually. Kirton's Adaption-Innovation inventory (KAI®), a highly reliable psychometric instrument that measures an individual's innate preference for structure, was used to assess each student's cognitive style[2, 25]. The Self-Assessment Manikin (SAM)[1], an ecological momentary mood assessment, was used to track fluctuations in the students' moods throughout the design thinking process. Correlations between these fluctuations in mood and cognitive style were examined to test our hypothesis that cognitive preference is a likely factor in variations in students' reactions and receptivity to design

thinking. We close with a discussion of the implications and limitations of this study for engineering educators, as well as directions for future research.

2.0 Cognitive Preferences and Design Thinking

2.1 Cognitive Style Diversity: Kirton's Adaption-Innovation Model

Cognitive style is defined as the strategic, stable, preferred way in which people respond to and seek to bring about change, including problem solving[2]. Among the theoretical frameworks proposed for understanding cognitive style diversity, Kirton's Adaption-Innovation (A–I) theory stands out in terms of its robustness and its elegance in explaining the complexity of cognitive style. In addition, the problem solving context in which A–I theory was originally developed makes its application in engineering straightforward and appealing. Perhaps as a result of these qualities, the use of A–I theory in engineering education research has grown in recent years, particularly through scholars investigating the impact of cognitive style within engineering problem solving and creative behavior[26, 27]. Following this chain of development, we are using A–I theory as our lens on cognitive style in this project.

Previous general studies suggest that more adaptive individuals tend to generate more detailed ideas that remain closely connected to the original constraints of a problem (digging deeper), while the more innovative tend to generate ideas that stretch the boundaries of the solution space in tangential ways [2]. As a consequence, we expect more adaptive students to be less comfortable and to struggle/cope more with problems and methods they perceive as loosely structured, while more innovative students are apt to be less comfortable and struggle/cope more with problems they perceive to be tightly constrained[2]. Viewed another way, we expect engineers who are "more adaptive" to prefer more incremental or "evolutionary" change, and engineers who are "more innovative" to prefer more radical or "revolutionary" change[2, 26]. These characteristic differences in preference produce distinctive patterns of behavior, although an individual can (and does) behave in ways that are not preferred; this is called *coping behavior*, which comes at an extra cognitive cost to the individual and can lead to stress and decreased performance[2].

2.2 Design Thinking

As Ulibarri et al.[22] note [p. 22]: "Design thinking is a set of mindsets and techniques for solving ill-defined, real-life problems, while nurturing and encouraging creative confidence"[22]. Within design thinking, there is a focus and push towards out-of-the-box solutions, innovative ideas, and revolutionary concepts[15, 23, 28]. This focus has been encouraged by industry, especially in light of the real-world success of the product development firm, IDEO, and the numerous products and tools they have produced[23]. The design thinking process, which is guided by an acute understanding of the user's wants and needs, can be used as a catalyst for innovation and bringing new ideas, products, and processes into the world. It is broken down into a highly iterative five-stage process that begins with empathizing with and defining the needs of your

user, moves into a rapid fire ideation stage, and wraps up with prototyping and testing concepts and solutions.

Previous studies have shown that design thinking can positively impact a student's creative confidence[21, 29], as well as their creative output[15, 22, 28, 23]. These studies were mostly based on qualitative data from case studies, however, and did not explore the effects of design thinking from a cognitive perspective. We hypothesize that the particular focus of design thinking on developing revolutionary (as opposed to evolutionary) solutions to complex design problems will make it more appealing to more innovative individuals as opposed to more adaptive individuals. In turn, we expect that these differences in appeal will lead to differences in levels of receptivity/resistance to design thinking as a methodology, as well as potential differences in actual performance. In the following sections, we discuss the details of our research methodology and the results of our work.

3.0 Research Questions

Design thinking to the best of our knowledge has not been explored in the context of cognitive style. The purpose of our work is to expand current knowledge about design thinking and its advantages and disadvantages in the context of engineering education. As discussed above, individuals different cognitive styles, and it may be unfair to expect all students to accept and excel at utilizing design thinking. Within this context, our work specifically focused on differences in cognitive style and how they affected students' moods throughout the course of a design thinking workshop. The SAMs mood assessment is composed of three separate scales: valence, arousal, and dominance[1], while KAI is a continuous measure. Our hypotheses with respect to these two measures are as follows:

- H_1: *More innovative individuals will score higher on the valence subscale.* We hypothesize that innovative individuals will be more likely to feel comfortable with the loose problem solving structure typical of design thinking[1, 15, 28, 29] and thus, feel happier throughout the workshop.
- H_2: *Arousal sub-scores for more innovative individuals will increase towards the end of the workshop.* We hypothesize that more innovative individuals will be more excited towards the end of the workshop, as compared with more adaptive individuals, because the final stages of the workshop stressed rapid ideations, prototyping and testing. In his work, Kirton points to the preference of more innovative individuals to generate more ideas that are less thought out, as compared to more adaptive individuals[2]. As a result, we feel that former group will become more excited following the ideation phase of the workshop.
- H_3: *More innovative individuals will score higher on the dominance subscale.* We hypothesize that more innovative individuals will feel more in control throughout the entirety of the workshop. We believe that design thinking plays to the strengths of innovators, and as a result, we feel that more innovative individuals will tend to feel more

in control of the situation and the tasks at hand, as compared to more adaptive individuals.

In the following section, we will review our research methodology, including a description of the study participants, the assessments used, and the workshop protocol.

4.0 Research Methodology

4.1 Study Participants

The purpose of this experiment was to understand the interaction of cognitive style on reactions and moods to the design thinking process throughout the course of a design thinking workshop. Participants were students at a large Midwestern university, who ranged in age and academic standing from first semester freshmen to graduate students. Approximately 50 students participated in the workshop, but because not every student completed <u>both</u> the Kirton Adaption-Innovation inventory (KAI) and the multiple instantiations of the SAMS scale, our final usable sample size was 30. Students voluntarily participated in the workshop as a part of an extracurricular student organization focused on new venture creation and entrepreneurship.

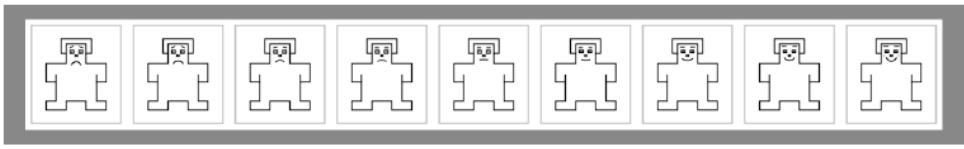### 4.2 Assessments Used in This Study

Self-Assessment Manikin Scale (SAMS): The SAMS is a "non-verbal pictorial assessment technique that directly measures the valence, arousal, and dominance associated with a person's affective reaction to a wide variety of stimuli"[1] (see Figure 1). It is based on the work of Mehrabian and Russell[30], who demonstrated that "emotions can be accurately described in terms of three independent and bipolar dimensions: pleasure-displeasure, degree of arousal, and dominance-submissiveness"[31]. The SAMS was chosen over verbal emotional assessments, because previous literature[2, 31, 32, 33] has shown that the visual representation of Mehrabian and Russell's[30] three-dimensional model allows efficient measurement across diverse audiences and provides an accurate model of the participants' emotional state at each moment in time[31]. The validity and reliability of SAMs have been tested in previous studies,[30, 31, 32] and it has been shown to be an accurate and reliable measure of emotional state.

The SAMS was conducted as a paper-and-pencil test; participants were asked to select and mark the manikin that best represented their current state on each scale. Each student was given a testing packet at the beginning of the workshop that consisted of a cover page with a user id (to preserve anonymity) and four separate sheets of the SAMS instrument. Respondents are asked to mark the manikin that best represents their current state and are provided with a range of emoticons representing emotional states. The valence subscale, which assesses an individual's relative happiness at that moment in time, displays emoticons ranging from very sad to very happy. The arousal subscale, which assesses and individual's relative excitement at that moment in time, displays emoticons ranging from very relaxed or sleepy, to very excited and dynamic. The dominance subscale, which assesses an individual's feeling of control in that particular
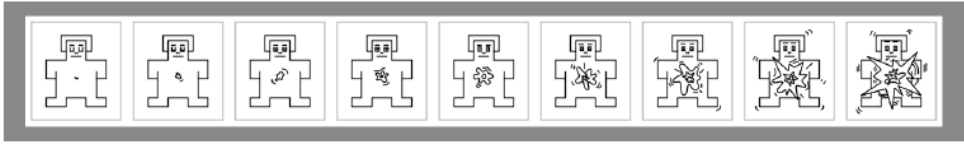
moment, displays emoticons ranging from very small (not in control) to very large (very much in control).

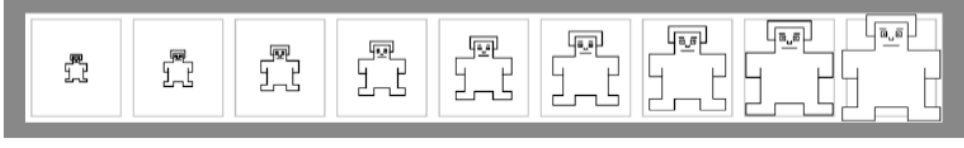**Figure 1: SAM the Self-Assessment Manikin[1] Used During the Workshop**

Kirton Adaption-Innovation Inventory (KAI): The KAI is a 32-item Likert-type scale, with scale anchors ranging from "very hard" to "very easy". The instrument prompts respondents to identify how easy or difficult they find it to present themselves consistently over a long period of time as a person who prefers certain conditions or engages in certain behaviors. For large general populations and across cultures, the distribution of KAI total scores forms a normal curve within the theoretical range of (32–160), with an observed mean of 95 (s.d. =17) and an observed range of (43–149); lower scores correspond to more adaptive cognitive styles, while higher scores correspond to more innovative styles. In terms of assessment, the internal reliability of KAI is high: 0.84 to 0.89 (mode of 0.87) over samples totaling nearly 3000 subjects from 10 countries[2]. Numerous validity studies have been completed for KAI, including content validation, factor analysis, and correlational analyses (see[2]: pp. 82–84; also Appendix 6, Tables

G & J). Wide ranges of KAI scores have been observed among both undergraduate and graduate students from a variety of engineering fields[26, 27].

In this study, the KAI was administered online and scored by a certificated practitioner. Figure 2 shows a histogram of the KAI total scores for the student sample; with a mean KAI score of 103.9 (± 12.6), this sample was distinctly more innovative in cognitive style than the general population (mean = 95) and engineers in general (mean = 96.8), as reported by Kirton[2].

Figure 2: Distribution of KAI[2] Scores across Sample
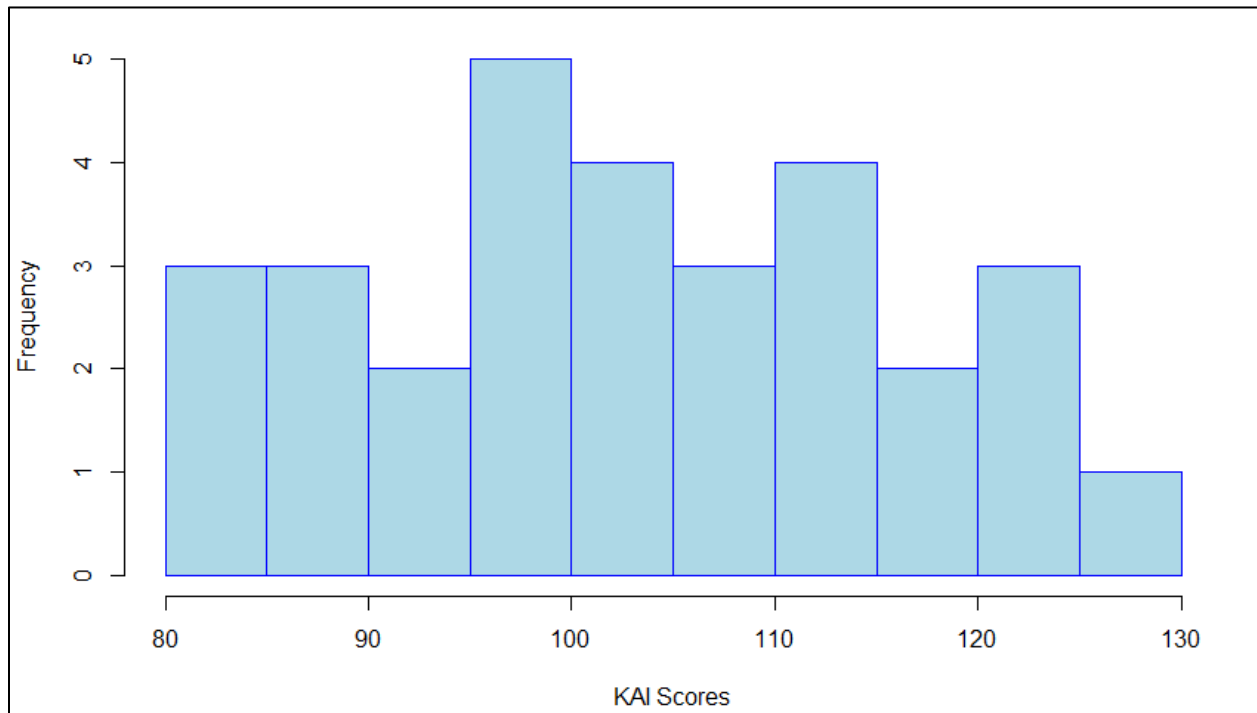
4.3 Workshop Protocol

The workshop was facilitated by the first author. Students were informed that their participation was voluntary and that they could opt out of the survey at any point if they wished. The workshop was structured around the principles of design thinking, and students walked through each phase of the process in order to solve the design problem provided. The design problem presented the students with a real-world problem that required systems-level thinking and out-of-the-box ideation. The purpose of the activity was not to create an ultimate solution to the design challenge, however, but to gain experience in design thinking methods. Students progressed through each phase of the design thinking process (empathize, define, ideate, prototype, and test) in a linear fashion. A brief description of the workshop activities at each phase is provided below:

Stage 1 – Empathize: The first step in the design thinking process, empathize with users, and was accomplished by introducing each team to a character or a user persona. This character or persona was to be used by the team to guide design decisions and concept development. Each team was asked to brainstorm a list of the user's needs, wants, goals, thoughts, and feelings based on the information provided in the character description.

Stage 2 – Define: Participants were asked to synthesize all of their user findings from the Empathize phase into one cohesive sentence. Students were given the following statement to fill in as an aid in this process: *[User] needs to [User's need] because [Surprising Insight]* [28].

Stage 3 – Ideate: Using the user statement as a guide, students were directed to dive rapidly into idea generation. Each team was given a packet of Post-It notes and asked to collaborate in order to come up with a variety of ideas. At this stage, it was stressed to each team that no idea was "stupid" or "impossible", and even wild ideas can help the team progress towards a solution. Teams were directed to vote on three of their favorite concepts and then proceed to prototype these concepts.

Stage 4 – Prototype: Teams were given approximately 20 minutes to create rough prototypes of their ideas. Supplies were provided, and teams were asked to create something visual, even if their concept was not a physical object.

Stage 5 – Test: As soon as teams had created a prototype, facilitators took on the roles of the team's characters and evaluated the designs. Teams were instructed to listen instead of defending their designs, and with the remaining time, iterate on their concepts using the feedback as a guide.

Workshop Debriefing: At the conclusion of the testing phase, a short summary of the benefits of the design thinking process was provided to participants, as well as a brief period for feedback on the workshop. Participants were able to express frustrations, inspirations, and general comments about the workshop in order to gain insights for future work.

In order to evaluate any fluctuations in mood/receptivity throughout the workshop, four brief data collection points were inserted into the protocol flow. These data collection points consisted of a call to stop work, after which participants were instructed to fill out the appropriate SAMS measure; each measure was labeled either as 1, 2, 3, or 4 to indicate the point in the workshop at which the measure was taken. Students were given three to four minutes to complete each SAMS assessment, after which the workshop continued. Figure 3 displays the workshop flow, highlighting the data collection points.

**Figure 3: Workshop and Data Collection Flow**
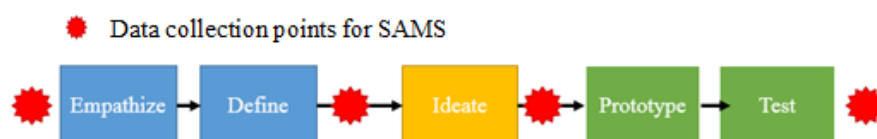
The SAMS was administered at these intervals (approximately fifteen to twenty minutes apart) to avoid survey fatigue. Although it would have been ideal to measure mood at the conclusion of every phase in the design process, we felt that this would exhaust the participants and could lead to misleading data due to survey fatigue. The empathize and define stages have a clear focus on the user and defining the user group, while the prototype and test phase are typically composed of very fast iterative cycles back and forth. As such, we felt that the empathize and define phases, as well as the prototype and test phases, were natural pairs of steps to link together and were ideal stopping points during the workshop.

5.0 Analysis and Results

All statistical computations were carried out using SPSS[34]. A repeated measures ANOVA was used to evaluate the relationship between cognitive style and mood measured at the four data collection points within the design thinking workshop. Scores from each of the subscales within the SAMs were treated as the independent variables, time was treated as the within-subjects factor, and KAI was treated as the between-subjects factor. Thus, three repeated measures were conducted on each of the subscales, with data points collected at the four separate time points.

A repeated measures ANOVA analysis was appropriate for our data, because we treated cognitive style as a stable characteristic of the individuals (consistent with A-I theory and validity evidence[2]) and measured mood data at multiple points in time. Specifically, the KAI scores were separated into four subgroups: adaptive, slightly adaptive, slightly innovative, and innovative. Cut scores for these subgroups were determined using the theoretical underpinnings of Kirton's work; Kirton specifies that the just-noticeable-difference for individual KAI total scores is 10 points. The mean KAI score for the sample was 103.6 and the four subgroups were defined relative to this mean: adaptive ranged from 84 to 94, slightly adaptive ranged from 95 to 105, slightly innovative ranged from 106 to 116, and innovative ranged from 117 to 127. Figure 4 highlights the samples distribution of KAI scores as compared with the general population. As you can see, this sample was biased towards the innovative end of the scale, which will be discussed further in later sections. In Figure 4, the sample distribution is shown in blue and the general population distribution is shown in red; the sample population has a higher peak shifted towards the innovative end of the scale, as compared to the general population.

Figure 4: Distribution of KAI Sample Scores versus General Population
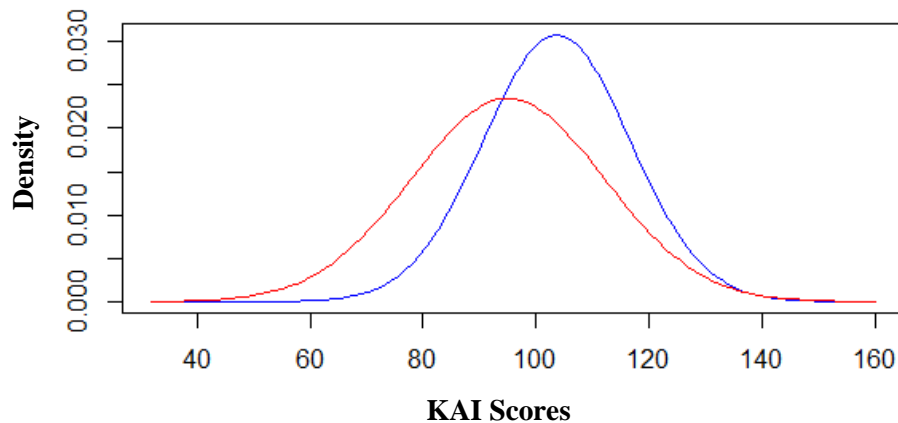
In this analysis, the following assumptions were made about the data: (1) there are no outliers in any group; (2) the data are approximately normally distributed; (3) there is homogeneity of variances; (4) there is homogeneity of covariances; and (5) there is sphericity. Although there were no outliers in our data, the assumption of normality was violated in some cases; this is explained further below. There was homogeneity of variances, as assessed by Levene's test of homogeneity[35], using a p-value greater than .05. There was also homogeneity of covariances, as assessed by Box's test of equality of covariance matrices ($p_1 = .408$, $p_2 = .480$, $p_3 = .036$) [36].

5.1 Assumptions

The first assumption was evaluated by inspecting a boxplot for each data set. In the initial evaluation, there were two outliers for each of the subscales, which were removed from the data. In order to evaluate the normality of the data set, a Shapiro-Wilk test was completed; this test was chosen (as opposed to evaluating skewness or kurtosis values) due to the relatively small sample size for this study. Because of the relatively small sample, we anticipated some violations of normality, especially after dividing the sample into four KAI-based subgroups. Repeated measures ANOVA is generally considered robust enough to withstand normality violations; thus, while normality was violated in some cases, we used the repeated measures ANOVA with the understanding that this was one of the limitations of our work.

Sphericity was evaluated using Machly's Test of Sphericity ($p < .05$)[37], and it was determined that the results for the repeated measures ANOVA with SAMS subscales 1 and 2 as dependent variables violated the sphericity assumption. The Greenhous-Geisser correction was used to correct for this violation[36]. The SAMS subscale 3 did not violate the sphericity assumption, so the assumed sphericity output from SPSS was used to indicate interaction effects.

5.2 Interaction Effects

There were statistically significant interactions between the KAI scores and the progression of the workshop on SAMS subscale 1, the valence subscale, (F = 2.582, p = .019, partial η^2 = .230) and subscale 2, the arousal subscale, (F = 2.851, p = .017, partial η^2 = .125). There was no statistically significant interaction between the KAI scores and the progression of the workshop on SAMS subscale 3, the dominance subscale, (F = 1.281, p > .05, η^2 = .045). Profile plots of each of the scales are provided in Figures 5-7. Reviewing each of the figures, the following observations can be made in relation to our original hypotheses:

- H_1: *More innovative individuals will score higher on the valence subscale.* While more innovative individuals tended to experience a steady increase in valence, according to the profile plot in Figure 5, the slightly adaptive subgroup experienced a much higher valence throughout the workshop. It can be seen, however, that all three subgroups aside from the innovative group, experienced a drop in valence during the prototype and test phase. More data and future experiments are needed to fully explore these findings, but at this time, this finding partially supports hypothesis one.

- H_2: *Arousal sub-scores for more innovative individuals will increase towards the end of the workshop.* Examining Figure 6, it can be seen that the innovative subgroup experienced a large increase in arousal or excitement as compared to the other three subgroups during the final stages of the workshop. This supports our hypothesis that more innovative individuals would become more excited during the ideation, prototype, and testing phases of the innovation process.

- H_3: *More innovative individuals will score higher on the dominance subscale.* Although there were no statistically significant correlations with the dominance subscale, by examining Figure 7, we can see that innovative individuals on average scored higher on the dominance subscale. While we cannot theorize about the reasons behind this, we feel it is necessary to explore this further in future work.

After establishing the existence of statistically significant interactions between the first and second subscales of the SAMS and the students' KAI scores, it was necessary to explore the simple main effects. Because the repeated measures ANOVA is an omnibus statistic, proper *post hoc* tests were required to determine which interactions were significant. For the first and second SAMS subscales, four separate between-subjects ANOVAs were calculated. These analyses revealed a statistically significant difference in valence (first SAMS subscale) between KAI scores at the fourth measurement – i.e., at the end of the workshop when the final SAMS scale was administered. For the arousal subscale (second SAMS subscale), there was a statistically significant difference at the third and fourth administrations between the adaptive and innovative subgroups (Groups 1 and 4). Specifically, the adaptors were significantly less excited compared to the innovators at both points in the design thinking exercise.

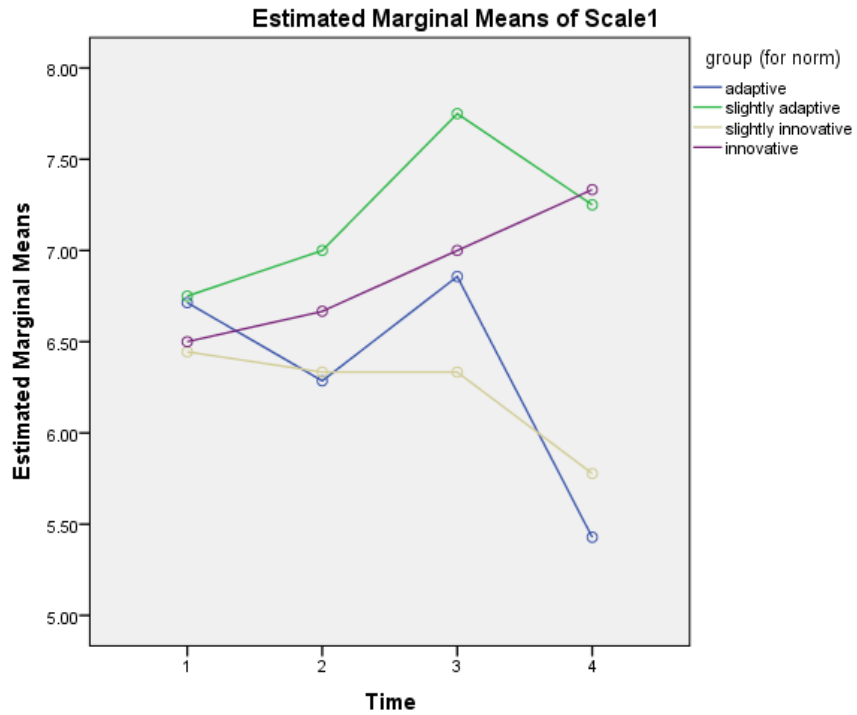**Figure 5: Profile Plot of Valence Subscale across KAI Subgroups and Time**

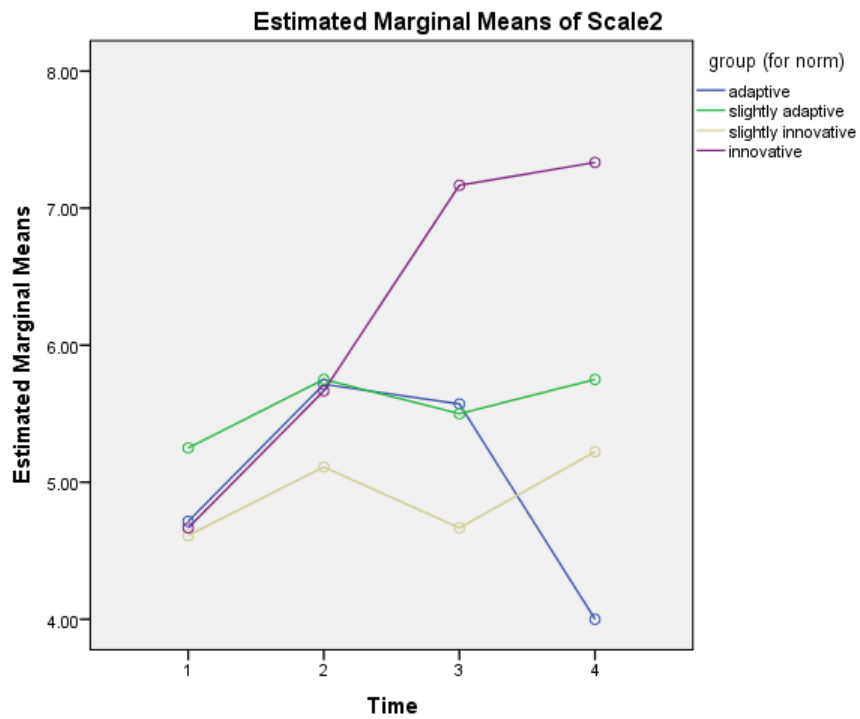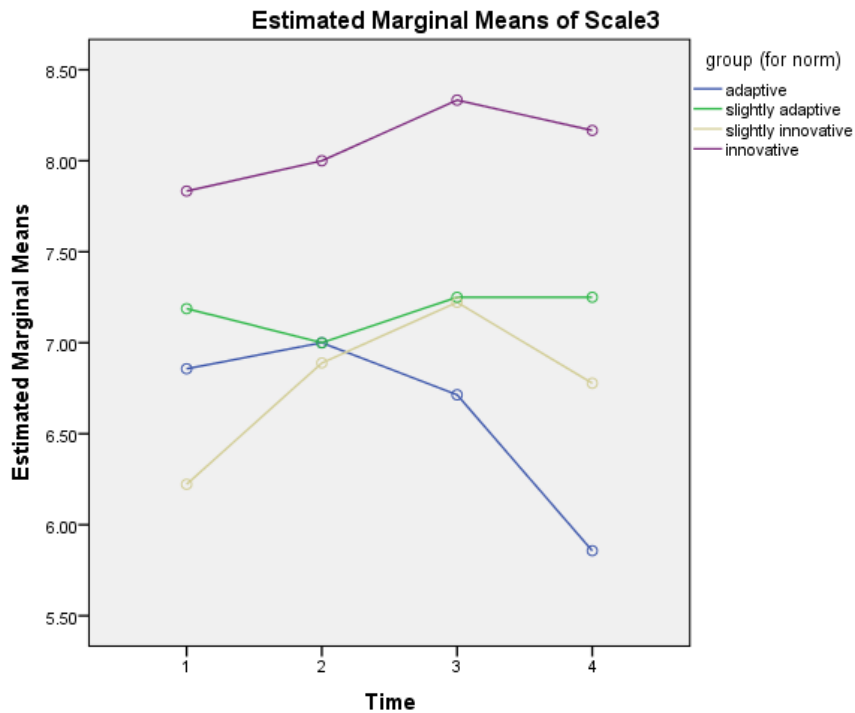**Figure 6: Profile Plot of Arousal Subscale across KAI Subgroups and Time**

Figure 7: Profile Plot of Dominance Subscale across KAI Subgroups and Time

6.0 Discussion of Results

The results of our analysis indicate that a statistically significant correlation exists between mood, cognitive style, and exposure time to design thinking. The purpose of this study was to explore how cognitive style affects mood during short term exposure to design thinking. Because of the small sample size, we will only make general observations; our hope is to continue to study these effects on a larger scale in future work.

Based on the statistical analyses discussed above, we found partial support for two of our hypotheses. The data indicate that innovators' valence may steadily increase throughout the course of the workshop, and this correlation should be explored more in further work. This finding, if validated in future work, could lead to interesting implications in engineering design education. If innovators are happier working with design thinking, and the opposite is true for adaptors (i.e., adaptors are more frustrated and depressed), this could imply that a shift in teaching methods is necessary. As a result, educators may see fit to teach certain methodologies depending on the cognitive style of their class, or teach a range of methodologies that cover a wider range of cognitive preferences.

We also found that a statistically significant correlation existed between the final stages of the workshop, KAI scores, and the arousal subscale. Our findings indicate that more innovative individuals from our sample increased in excitement levels compared to the other three subgroups. This excitement in terms of an engineering classroom could relate to interest level in

the subject matter and potentially to academic performance. We also noticed a trend in the dominance subscales for more innovative individuals to feel more in control throughout the workshop as compared with more adaptive individuals. Although this was not a statistically significant finding, we feel future work should explore this trend further on a larger and more diverse sample.

7.0 Limitations and Implications for Future Work

Our study was limited in its scope due in part to the self-selection bias of the participants and the size of the sample studied. As mentioned previously, our participants were members of a student organization focused on innovation and entrepreneurship. Referencing Figure 4 again, we see that the mean KAI score for our population was shifted towards the innovative end of the subscale. If a more representative sample of the general population had been used, we may have seen different relationships in the data. Therefore, in future work, we will explore different populations in order to gain a better understanding about how different groups react and utilize design thinking. Because this is a preliminary study, the size of our sample, approximately 30 participants, was small. This sample was broken down even further into four subgroups, which most likely affected the analysis even further. In order to get more conclusive results in future work, we will explore these trends with a larger sample size.

Our observations suggest that individuals with different cognitive styles do experience different moods in response to an experience with design thinking. Expecting students to perform at similar levels, while certain students are experiencing a higher cognitive load (due to higher levels of coping behavior), could lead to misrepresentations of a student's capabilities. Our findings suggest that in some way, student receptivity to new design methodologies is linked to cognitive style. This could mean a shift in engineering design education, from an emphasis on one particular methodology to an emphasis on multiple methodologies that relate best to an individual's cognitive style, is necessary. The extreme case could be made that if frustrated enough, students may shift away from engineering design, where design thinking is being utilized, in favor of other fields of work. Industries, organizations, and society in general requires both adaptive and innovative individuals working together to properly function. It would be extremely unfortunate if adaptive individuals are driven away from the design process due to an over-emphasis on an innovative problem solving methodology, such as design thinking. We feel that these findings add to the understanding of engineering education, specifically engineering design, and how new design methodologies could affect student performance. It may be ideal to mix and match methods, tools, and techniques for each student in order to find the optimum design process. Although a seemingly daunting task, the possibilities that result from every student using a unique design process that optimizes their innovative output, are endless.

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