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Culturally Responsive Engineering Education: Creativity Through ”Empowered to Change” in the U.S. and ”Admonished to Preserve” in Japan

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Culturally Responsive Engineering Education: Creativity through "Empowered to Change" in the US and "Admonished to Preserve" in Japan

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Abstract:
Enhancing creativity is an indispensable goal of many engineering courses. However, with flourishment of global collaboration in various engineering classrooms and best educational practices being replicated across cultures, there are not many curriculum interventions that originate from students' diverse cultural needs. When cultural differences are ignored, students may get culturally biased grades and face confusion and difficulties. For instance, the notion of "disruption" and "breakthrough" in product design innovation is culturally and locally shaped in the U.S. and might be considered undesirable in Japan. For example, Japanese students coming to a U.S. university for a co-final presentation with their U.S. student partners may get ill-evaluated due to lack of articulation on how their ideas break through the status quo. This is problematic given that student evaluation is less based on traditional exams of fundamental science knowledge, but rather increasingly subject to culturally-shaped experience.

The paper is centered around the idea that engineers are motivated by the cultural values with which they identify. In the U.S., the motivation to promote change is widely held to underpin the generation of new ideas and value creation. In contrast, preservation is perceived as demanding but taken very seriously in Japan and change from this perspective can be seen as an unconstrained, irresponsible mission that requires less effort.

The paper empirically examines the cultural dimensions of creativity in engineering education, specifically how engineering students' motivations for creative problem-solving are different in the U.S. than in Japan. A cross-cultural survey study was designed and run to test the hypothesis that Japanese (U.S.) engineers are more (less) motivated to create new ideas when they are asked to preserve rather than change something. We will share the encouraging preliminary results and discuss implications.

Engineers across different cultures have the capacity of both – create to change, and create to preserve. But different cultures emphasize different values. If engineering educators (and managers at organizations) of a certain sociocultural context celebrate their cultural values and restrict others, either consciously or not, this would put people with different values at disadvantage. With the salient power dynamics between educators (managers) and students (junior employees), this means alienation, misjudgment and disconnection. The paper underlies the importance for educators to learn about the different cultural forces behind different engineering behaviors. The research contributes to the cross-cultural literature of engineering education.

Keywords: cross-cultural study; creativity; culture of design education; cultural motivation.

1. Introduction

Students from different backgrounds carry with them different culturally-constructed values, practices and knowledge that are relevant to their learning of engineering. Students are more engaged and more likely to be successful when their cultural ideas, practices and knowledge are acknowledged and supported in classrooms and college communities. But what if their values and understandings are repeatedly ignored or discouraged (Felder & Brent, 2005; Choi, 2010; Medin & Bang, 2014; Rivard, cited in Kizilcec, et al., 2017)? In the U.S., we think about "change lives; change organizations; change the world" (Stanford Graduate School of Business motto) and "change by design" (Brown & Katz, 2011) as the default. Therefore, *change* motivates our students to create, innovate and make impacts. What is often neglected, however, is to which extent this cultural value echoes with students from other cultural backgrounds. When *change* (e.g., come up with ideas to *transform* education) is stated as the primary goal but one's creative processes are less motivated by *change*, which could be the case in students from other cultural backgrounds (e.g., come up with ideas to sustain education), students could be seen as less creative.

The current paper aims to examine stereotypes of creativity by understanding cultural values of students from underrepresented groups in the context of creative problem-solving. Although creativity is gaining popularity in engineering education research and is considered a core component of globally engineering competencies (Lucena, et al., 2008), to our knowledge, no studies in our field have yet investigated its intercultural dimensions. The current research addresses the gap by examining motivational differences of creative problem-solving between American and Japanese engineers. We will first review cross-cultural literature of engineering education and creative problem-solving that have examined differences between Western and East Asian students. We will then present a survey study that compares cultural values of American and Japanese engineering students in the context of creative problem-solving. Our ultimate goal is to promote deeper cross-cultural understandings of creativity and provide actionable guidance for the teaching and learning of creative design capabilities.

2. Research of Culture Difference in Engineering Education

Culture plays a constructive role in engineering identity, behavior and ability (Rover, 2008; Markus & Hamedani, 2019). Traditionally, however, partly due to the perceived rationality of engineering science and its practice (Vincenti, 1900; Bucciarelli & Kuhn, 2018), the cultural nature of engineering practice (i.e., engineering is cultural) is greatly undermined (David, 2018). In multicultural engineering work settings, minority groups are left with the default option to learn and adapt to the dominant cultural values (Choi, 2010). For instance, East Asian students' cultural values are often undermined when clashing with the mainstream views in the U.S. (Kim & Markus, 2002). In formal learning settings, minority students are differentially positioned to having less access to particular resources and associated learning experiences that are crucial for their development (Nasir, et al., 2020). Felder and Brent (2005) observed that many good students drop out of engineering programs because of dissatisfaction with the instruction they receive that fail to match the cultural expectations and orientations.

In response to the rising demand of international workforces and increasing call for diversity and inclusion, more and more cultural studies have emerged in the last twenty years. A few trends are observed in the cultural research of engineering education. A majority of these studies have focused on designing globalized curriculums or learning models (Fruchter & Townsend, 2003; Daniels, et al, 2010; May, et al., 2015; Hazelton, et al., 2009). Fruchter and Townsend (2003), for instance, designed an inclusive curriculum to accommodate the diversifying student body. Another trend is cross-cultural comparison studies of educational practices and values in either history or present days (Downey, et al., 2006; Zhou, et al., 2015; Kunioshi, et al., 2019). For instance, Downey and his colleagues (2006) discovered engineering education reformers in the U.S. focus on introducing design into engineering problem-solving, whereas European educators focus on preparing students for career mobility by restructuring degrees, expanding nontechnical contents and creating student-exchange programs. Zhou and her colleagues (2015) found a push-pull difference of teacher-student relationship between China and the U.S., in that teachers are regarded as the owner of learning and need to push their students to learn in China, whereas U.S. students perceive themselves to be the owner of learning. Less research is focused on the culturally-shaped values and orientations of engineering learners themselves. Drawing on a learning pathway perspective, Nasir, et al., (2020) analyzed how idiosyncratic upbringings and educational cultures would channel engineering students' learning process, and shape their engineering identity, experience and career. Amongst the limited studies, Gorodetskaya, et al. (2016) surveyed mid-West American, South American, and central Russian students who were found to have culturally-contingent, local context-related motivations to learn engineering. Downey & Wada (2011) reported their observations of the last century that instead of being perceived as an engineer, Japanese engineers would gain professional identities according to the industrial household to become, for instance, "Toshiba men" or "Hitachi men", as they joined Toshiba or Hitachi. This idea is also supported in Dore and Sako (2012), where Japanese engineers were observed to be motivated to gain competence in performing their present or likely future jobs within the firm (due to a lifetime employment culture, Lorriman, 1986), whereas self-marketability was observed to be more common amongst American engineers.

3. Cultural values underlying problem-solving and creativity

Shifting lenses to the specific educational goal of fostering creative design capability, there is a rise of creativity research in engineering design education, as reflected in growing research in curriculum design (Zhou, 2012), creativity-facilitating intervention (Hawthorne, et al., 2014) and creative behavior and cognition (Toh & Miller, 2014). However, we lack a deep understanding about different, and possibly conflicting, cultural beliefs and practices around creative problem solving amongst students from different cultural backgrounds.

Broadly speaking, in cultural psychology, researchers have found that East Asians tend to have interdependent self-construals (Markus & Kitayama, 2010; Markus & Hamedani, 2019), be more holistic thinkers (Nisbett, et al., 2001) and self-criticizers (Kitayama, et al., 1997), and prefer calm rather than excited emotion (Tsai, 2007). The findings about East Asians are also found in other cultural groups that value interdependence more than independence. By contrast, Americans tend to have independent self-construals and positive self-regard, be more analytical thinkers, and prefer excited emotions as their ideal emotions (Markus & Hamedani, 2019). Creativity in the West is often represented and exercised as "progressing forward" (Lubart, 1999), seeking structural and social freedom (Osborn, 1961; Amabile, et al, 1996) and "defying the crowd" (Stenberg & Lubart, 1995). Changing the external situation is symbolic of individual agency in the U.S. For instance, "The wind of freedom blows" marks the opening of Stanford University's ViewBook (2009); "Free from boundaries of tradition," the university "attracts forward-looking, forward-thinking people — people whose entrepreneurial attitudes refuse limits and resist assumptions" and gives students "the freedom to be themselves: innovative, creative, unconstrained by any predetermined look or affect" (cited in Plaut, et al., 2012). In contrast, far less empirical examination is done about East Asians who may hold different beliefs that creativity is less activated by changing and disrupting, but rather by returning to the origin, building upon the tradition and connecting with the crowd (Lubart, 1999; Kuo, 1996; Chung-Yuan, 1963; Yukawa, 1973; Sundararajan & Raina, 2015; Paletz, et al., 2011; Misaki & Ge, 2019).

Group relation is a big source of agency in Japan, as compared with individual agency in the U.S. The self-other interconnection pushes forward the embracement of admonishment and self-criticism in Japan (Kitayama, et al., 1997; Heine, et al., 2000). "I believe creativity is born by pushing people against the wall and pressuring them almost to the extreme", said an executive at Honda (Takeuchi & Nonaka, 1986). The approach is not likely to be embraced by the contemporary engineering educators in the U.S., because it is perceived to kill the enjoyment, interest and satisfaction that are considered necessary for unleashing creativity. For instance, in design thinking, which originated in the U.S., facilitators often arouse excitement and create fun experiences to lubricate creative idea generation exercises. Legg (1989, cited in Downey, et al., 2006) noted that successful engineering problem-solving in the U.S. often includes demonstrating individual ingenuity, drive, and initiative, while in Japan the successful solution of an engineering problem often includes demonstrating that one is fulfilling obligations to some greater whole.

Emerging studies outside our field of engineering education have been done about culturally different psychological tendencies of college students in creative idea generation, problem-solving and science learning settings. Tweed, White and Lehman (2004), for instance, found East Asian participants are more likely to use internally targeted control attempts, i.e., attempts to accommodate the demands of the environment, to deal with stressful problems-solving situations; by contrast, Western English-speaking participants coped with problems by altering the environment. In one study, Saad, et al. (2015) found that, despite their ideas being rated more original by experts, Taiwanese students were less confident in their own ideas than Canadian students. A similar finding was found in Wang, et al. (2018) comparing Taiwanese and American students in science learning settings. And a study by Kim (2014) confirmed the aforementioned self-criticism assumption that East Asians use self-deprecating talks between members to form "oneness" and thus bonding teamwork. Medin and Bang (2014) did a few studies to explore the cultural values of Native American learners and how they clash with the dominant culture of White Americans. In a vivid example, Medin and Bang depicted a Native American child being failed by the Western science paradigm-based instructions — the Western paradigm favors direct answers while having little patience and appreciation of the contextual approaches to science problem-solving, the latter of which is more dominant and rooted in Native American cultures. These research insights demonstrate how cultural values underlie the sociotechnical processes of creative problem solving and have important implications for our research and diversifying engineering education.

5. Research Question

To our knowledge, no cross-cultural study has been done to explore how engineers' creative processes are shaped by culturally different connections to the physical, social and historical environments. Given that quite a few cross-cultural empirical studies are done in psychology to examine tendencies of self-criticism and self-enhancement, we want to focus on the little researched phenomenon of change and preservation as motivations of creativity. The reviewed research suggests that American cultural ideas promote the notion to *change*, *alter*, *transform* and *disrupt* situations for the better, whereas East Asian cultural ideas highlight the importance of *preserving*, *sustaining*, *maintaining* and *reviving* situations for the better. In other words, depending on the sociocultural contexts, one's creative process can be activated either by *change* or by *preservation*.

In the context of engineering design, engineers constantly need to create new ideas, design new solutions and solve problems along the design process in creative ways. What drives engineers to create new ideas and solve problems? Due to the lack of research around how change and preservation serve as motivational forces for creativity, we have formed a survey study to empirically examine it.

When the goal of an ideation task is framed to be consistent with the predominant cultural values that engineering students subscribe to, would it yield a strong motivation for them to work on the creativity task? Our research question is composed of two hypotheses and an explorative question:

1. H1: Engineering students in Japan are more motivated to generate new ideas when the task is framed as to preserve rather than to change situations.

   H2: Engineering students in the U.S. are more motivated to generate new ideas when the task is framed as to change rather than to preserve situations.

2. How are these cultural motivation differences, if any, constructed?

We address the research questions with a between-subject factorial design-based survey that mainly involves an idea generation task with two different problem framings, i.e., come up with a new idea to preserve or to change a certain situation. We elaborate on the survey study in the next section.

6. Method

6.1. Participants

178 Japanese and 239 American college students of engineering majors participated in our online survey. The Japanese engineering students were undergraduate and graduate students from a private engineering university in Tokyo, Japan, and the American students were recruited from Prolific[1] based on the screening requirement of U.S. citizens and current students of engineering majors such as mechanical engineering, electric engineering, computer science and biomedical engineering. After cleaning up with attention checks, we have in total 158 Japanese engineering students (7 female, 149 male, mean age = 19.96) and 209 American engineering students (80 female, 128 male, 1 other, mean age = 24.3) who have completed the survey. Amongst the American participants were White American: 56%, African American: 10%, Latino American: 14% , Asian American: 27%, Native Americans: 2 and Pacific Islander: 1. Based on a single subjective socioeconomic status measure (0 - worst off to 10 - best off), we retrieved the subjective socioeconomic status, which was comparable between Japanese participants (mean = 6.39, SD = 1.94) and American participants (mean = 6.35, SD = 1.72). The participants took the survey in 2020 after the COVID-19 pandemic started.

6.2. Procedure

After reviewing and agreeing to the consent forms, participants were asked to come up with a new idea to solve a problem and write down their ideas using between 300 to 800 characters (150 to 400 Japanese words). To increase generalizability, each participant is randomly presented with one of six different problem topics from a corpus of topics by stimulus sampling (Wells & Windschitl, 1999). Problem topics include designing solutions to change or preserve a local park, local transportation, career path, how to do exercises, how New Year is celebrated, the way you interact with a good friend living in a different city and how recycling is done in your neighborhood. The

[1] https://www.prolific.co/

problem topics are not constrained to be engineering problems, because this study belongs to a larger research project where we are examining our research questions in broader populations, including people from other disciplinary backgrounds and of different ages. The generic problem topics would allow cross-disciplinary comparison of cultural motivations, for instance, between engineers and business people. Participants were randomly assigned to one of the two conditions: to change or to preserve the situations, and they were given specific definitions of the two terms. If they are assigned to the preservation condition, the survey item is presented for example as:

> *Please come up with a new idea to preserve a local park. In a few sentences, briefly describe your idea in the box below. There are no right or wrong answers to this question.*
>
> *To preserve means to enable something to continue (持続させるとは、それを維持させることを意味します).*

In the change condition, the question is presented for example as:

> *Please come up with a new idea to change how you interact with a good friend who is living in a different city. In a few sentences, briefly describe your idea in the box below. There are no right or wrong answers to this question.*
>
> *To change means to make or become different (変えるとは変化させること、違うものにすることを意味します).*

After completing the idea generation question, participants were asked to rate their motivations when generating the idea, novelty and usefulness of the idea, as well as answer a few other questions about their psychological tendencies and demographic information. U.S. Participants received the survey in English, and Japanese participants received the same survey in Japanese, which was translated and validated with the help of a few Japanese colleagues including some of the current authors.

6.3. Measures

Motivation for idea generation: We used three items to measure motivation: 1). How driven were you to come up with the idea? 2). How important was it for you to come up with the idea? 3). Overall, how much were you willing to put efforts into coming up with the idea? Participants answered these questions based on a 5-point scale (1 = Not at all to 5 = Extremely). The items formed a reliable composite (Cronbach's alpha = 0.88 and 0.67 for American and Japanese participants respectively).

Self-appraisal of creativity and liking of ideas: We used the standard three-item measure of the self-perception of the quality of the idea's creativity: 1). How novel was your idea? 2). How useful was your idea? 3). Overall, how creative was your idea? Participants answered these questions based on a 5-point scale (1 = Not at all to 5 = Extremely). The items did not form a reliable composite for Japanese participants (Cronbach's alpha = 0.59) and were acceptable for U.S. participants (Cronbach's alpha = 0.72). Due to lack of enough correlation between the items, we examined the three measures of creativity separately. We also used a one-item question 1) How much did you like your idea? to measure the liking of their own ideas.

Individual difference measures: We used a series of measures to explore individual difference including individualism (Singelis, et al., 1995), belief of the source of change (i.e., on a scale from 1 = completely from individuals to 7 = completely from context or factors external to individuals, where do you think changes come from?), the level of societal change (i.e., on a scale from 1 = not at all to 5 = extremely, in your opinion, to what extent are changes happening in society today?), holistic attention (Choi, et al., 2007), value of tradition (drawn from World Value Survey -WVS), and openness to experience (John & Srivastava, 1999).

7. Results

Descriptive statistics summarizing data of all measures of Japanese and American engineering students are presented in Table 1. As shown in Table 1, across conditions, American engineering students' reported motivation for generating ideas ($M = 3.43$, $SD = 0.93$) is higher than Japanese engineering students' ($M = 2.98$, $SD = 0.77$) ($t(362) = 5.11$, $p < 0.001$), suggesting that American engineering students were more motivated to generate ideas than Japanese engineering students regardless the problem was framed as to preserve or to change situations. In a similar way, American engineering students reported higher levels of creativity ($t(361) = 4.74$, $p < 0.001$), novelty ($t(352) = 3.96$, $p < 0.001$), usefulness ($t(334) = 6.66$, $p < 0.001$) and liking ($t(329) = 8.11$, $p < 0.001$) of their own ideas across conditions than Japanese engineering students.

As for other individual difference measures, American engineering students reported higher levels of individualism ($t(323) = 13.87$, $p < 0.001$) and openness to experience ($t(330) =$

8.08, p < 0.001), and were less likely to perceive that the source of change comes from context (t (326) = -4.65, p < 0.001) than Japanese engineering students.

Table 1 Descriptive results for all variables. American engineering students reported higher levels of motivation, creativity, novelty, usefulness and liking of their ideas, individualism, openness to experience, and perception of the source of change than Japanese engineering students. The differences were all statistically significant.

	Japanese Eng. students			American Eng. students			Scale
	Mean	SD	Skewness	Mean	SD	Skewness	
Motivation	2.98	0.77	-0.25	3.43	0.93	-0.08	1 - 5
Idea creativity	1.99	0.90	0.90	2.48	1.08	0.50	1 - 5
Idea Liking	2.57	1.08	0.43	3.48	1.03	-0.22	1 - 5
Idea Novelty	2.01	1.01	0.99	2.44	1.10	0.47	1 - 5
Idea Usefulness	2.78	1.07	0.34	3.53	1.04	-0.36	1 - 5
Individualism	4.33	0.94	0.20	5.66	0.87	-0.68	1 - 7
Holistic Attention	4.84	0.80	0.14	4.79	0.97	-0.32	1 - 7
Openness to experience	4.31	0.91	-0.58	5.07	0.87	-0.17	1 - 7
Societal change	3.42	1.10	-0.28	3.53	0.90	-0.21	1 - 5
Source of change	4.61	1.42	-0.41	3.94	1.33	-0.02	1 - 7
Value of Tradition	2.15	0.92	0.44	2.16	1.10	0.73	1 - 5

In the factorial design analysis, we controlled for which topic of idea generation participants were randomly assigned to. As shown in Figure 1, we find Japanese engineering students were more motivated to generate ideas when they were asked to preserve rather than to change situations (t (151) = 1.88, p = 0.062). But there is not statistically significant difference between conditions for American engineering students (t (202) = -0.6, p = 0.5), suggesting that American engineering students in the sample were equally motivated by preservation and change. There was a trending interaction between our manipulation of the problem framing and participants' national backgrounds in predicting their motivation for idea generation (t (357) = -1.63, p =0.1), suggesting that the effect of different problem framings (i.e., to preserve or to change situations) on motivation level is likely to be dependent on cultural contexts (i.e., Japanese or American).

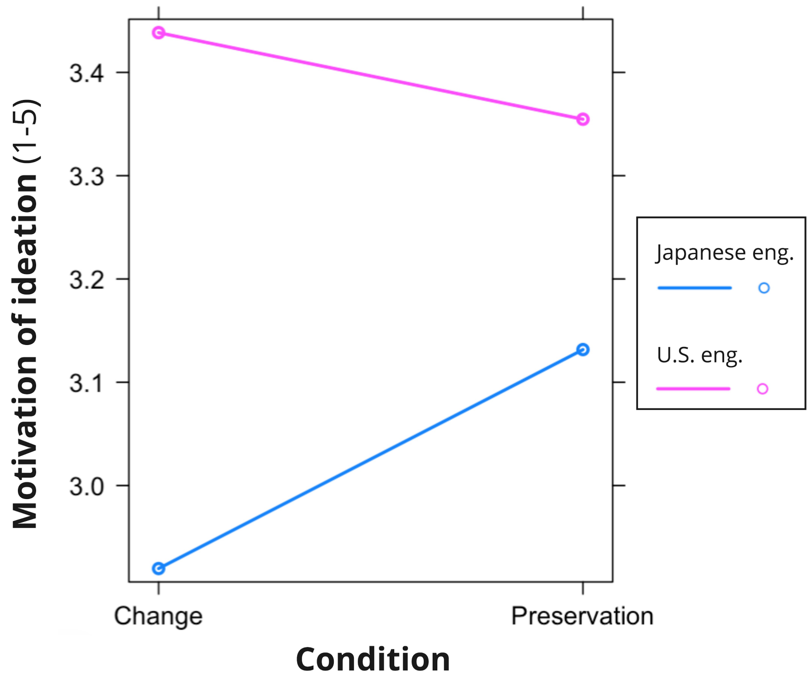

Figure 1. Motivation for idea generation between Japanese and American engineering students across two conditions — change and preservation. American students are more motivated to generate ideas than Japanese students across conditions ($t\ (362) = 5.11$, $p < 0.001$). Japanese students were more motivated by preservation than change ($t\ (151) = 1.88$, $p = 0.062$), but no difference is observed between conditions in American students. There is a trending moderation effect of cultural context on the relation between problem-framing manipulation and motivation for idea generation ($t\ (357) = -1.63$, $p = 0.1$).

To understand how the differences of motivations around idea generation are constructed, we explored into variables of individual differences. We find a trending interaction effect between problem framing and people's perception about where changes come from ($t\ (357) = 1.66$, $p = 0.0987$). In other words, the effect of problem framing on the motivation around idea generation is likely to be qualified by the interaction with people's perception about where changes come from. As shown in Figure 2, when people perceive change comes from the context, they are more likely to be driven by preservation-based problem framing rather than change-based problem framing. By contrast, when people perceive change comes from individuals, they are more likely to be driven by change-based problem framing rather than preservation-based problem framing. A marginal interaction effect ($t\ (357) = 1.8$, $p = 0.0724$) is also observed in predicting self-appraisal of idea creativity, where the effect of problem framing is moderated by people's perception about where changes come from. No other variables, such as openness to change and individualism, are found to moderate the relation between problem framing and motivation.

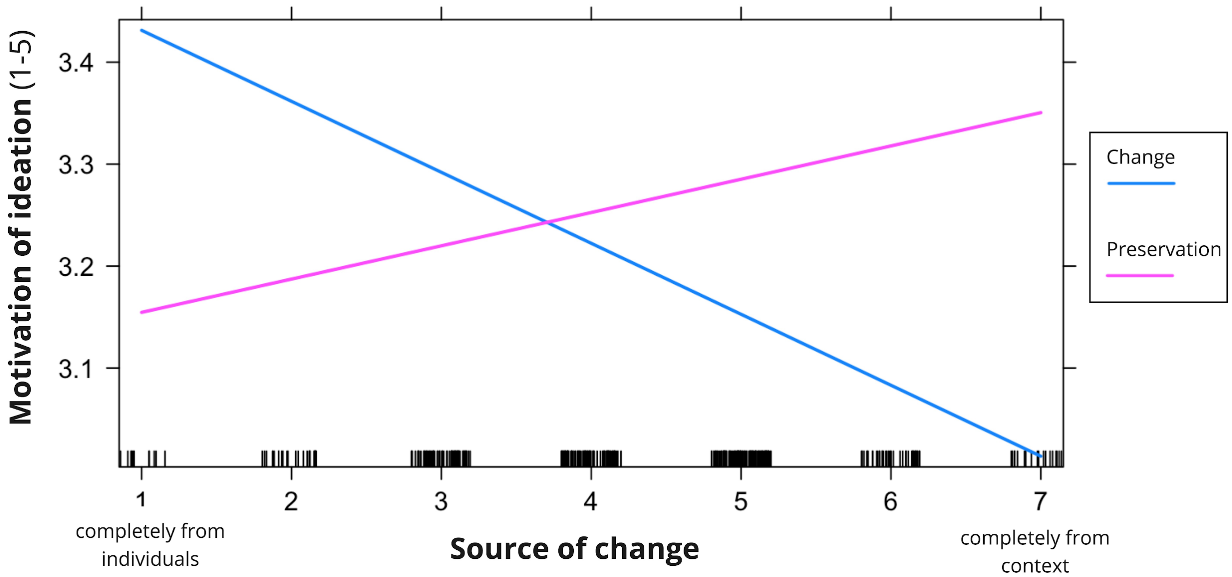

Figure 2. Trending interaction (t (357) = 1.66, p = 0.0987) between problem framing and people's perception about where changes come from, in predicting motivation for idea generation.

7. Discussion

We have conducted a between-subject factorial design-based survey study to examine the motivational differences between Japanese and American engineering students when idea generation problems or tasks are framed differently. Are Japanese engineering students more motivated to solve the same problem when the goal of the problem is framed as preservation rather than change? Does the opposite hold for American engineering students? The study provides a positive answer to the first question (H1) but not the second question (H2). We find Japanese engineering students are more likely to be motivated to generate ideas when the goal of the problem is framed as preservation (e.g., come up with ideas to preserve local transportation) than when the task is framed as to change the situation (e.g., come up with ideas to change local transportation). The opposite doesn't hold for American engineering students. On the other hand, we find American engineering students in general tend to be more motivated to work on idea generation tasks than Japanese engineering students. In terms of idea appraisal, American engineering students tend to rate higher creativity, novelty, usefulness and liking of their own ideas than Japanese engineering students.

We have also explored how these motivation differences are constructed, and found a trending moderation that problem framing has a stronger effect on how much motivation they have to solve the problem when people take a stronger position in how individual versus context plays a role in making change happen. The study does show that Japanese engineering students are much more likely to think change comes from context. While American engineering students are less likely to think change comes from context, their score (M = 3.94, SD = 1.33, based on a scale from 1 to 7) is not low either. That may explain why the American engineering students were equally likely to be motivated by preservation and change.

7.1. Japanese motivation to preserve, viewed from different relations between self and context

The finding of Japanese engineering students' stronger motivation to preserve than to change strengthens the perspective that people in Japan tend to have a more harmonic and inseparable relationship between self and context (e.g., other people, the environment) (Markus & Hamedani, 2019; Legg, 1989, cited in Downey, et al., 2006; Tweed, White & Lehman 2004) and that Japanese self-perceive to be adaptive and are willing to be changed, instead of changing others (Kitayama, et al., 1997). We find a marginal moderation effect that problem framing's effect on problem-solving motivation is dependent on people's perception whether change comes from context or individual. As a result, we can reasonably conjecture that the cultural conception that self is constantly changed by the context partly explains why preservation/change-based problem framings affect motivation differently for the Japanese students.

7.2. American motivation to preserve and change

Conversely, in American cultures, self is often construed and practiced as different and separated from context (e.g., other people, the environment) (Markus & Kitayama, 2010). The high individualism score amongst American engineering students in our study supports this view. Although the cultural practice to exert individual agency to *change* others and alter the external environments for the better is reported in literature, the current study does not have any evidence showing American engineering students are more motivated to change than to preserve. To understand how our second hypothesis was not supported, i.e., why American engineering students were equally motivated by change and preservation, we list a few possible explanations. First, the sample from Prolific may represent American engineers of broader and more multicultural backgrounds, given the heterogeneity of cultural values and practices in the U.S. (Plaut, et al., 2012); Change orientation might be stronger in certain subcultures in the U.S., such as in the middle class in Silicon Valley. Second, our assumption that American engineers are more motivated to change than to preserve situations is limited or the survey design is limited. It might be that engineers in the U.S. are equally driven to preserve certain situations, and it could be that the survey design does not necessarily stimulate relevance to real-life scenarios where the drive to change the status quo is stronger. Fourth, because our survey is taken under the pandemic, which has dramatically influenced our work and life, people may think there is a greater need to preserve circumstances under the threat of pandemic. On the other hand, given this fourth assumption, we still observed American engineers are more motivated to change than to preserve, although the result is not statistically significant. Taken together, the study result provides meaningful evidence for cross-cultural differences and lends insights on how cultural ideas, practices, interactions and beliefs push forward different cultural practices and values around creativity and are in turn reinforced by them.

7.3. Different meanings of change and preservation in different cultural contexts

Change and preservation could entail very different meanings and connotations in different cultural contexts. In the U.S., an example of exerting changes is critical thinking. However, while the ability and skills of critical thinking is prioritized in American education, it is much less valued in Japanese education. This is exemplified by the TALIS 2018 report (OECD, 2019) of lower secondary teachers, where teaching critical thinking is valued only 24.5% in Japan compared to 79.5% in the United States. In replacement of critical thinking, criticism thinking is prevalent in Japan where people practice self-criticism to change themselves, instead of changing others (Kitayama, et al., 1997; Kim, 2014). The criticism thinking of Japanese and the self-enhancement of Americans may partly explain why American participants were in general more motivated and think more highly of their ideas in the current study. Notably in the study by Saad, et al. (2015), even though the Taiwanese students' ideas were self-rated less original than the Canadian students', the ideas of the Taiwanese were more highly rated by experts. Similarly, preservation seems also to have a different target in Japan than in the U.S. Preservation is motivating in Japan because it activates the collective agency to maintain, sustain and revive tradition and good practices to fulfill obligations for the greater whole. In the U.S., preservation is likely to activate individual agency, such as shown in superhero movies, where protagonists exert their individual agency to preserve the world from external threats. Change may have a less positive connotation in Japan than in the U.S., and the opposite might hold for preservation. Anecdotally, we learnt from an American design educator that the term "disruptive innovation" was frowned upon by some Japanese participants during a design thinking workshop that he helped organize in Japan recently. In Japan, people tend to believe the act of changing the situations is irresponsible, whereas preservation is an important job although it is perceived as difficult. A great example of preservation-inspired creativity is Kengo Kuma, an internationally renowned Japanese architect who has designed the Olympic game stadium for Tokyo 2020. Kengo Kuma's modern designs have been motivated by the perceived strong connection to the natural environment and Japanese tradition (Kengo Kuma). In his own words, "architecture should cease to force itself onto a landscape and should instead, through acquaintance with local materials and methods, relate itself harmoniously to its surroundings" (Saval, 2018).

7.4. Implications for engineering design education

How mindful are our teachers of the implicit cultural values of students in our college classrooms and graduate schools? How aware are we about the possible influences of problem framing on effort and motivation students would have on solving the problems? Our study shows that there are important cultural differences between American and East Asian students that educators should be mindful of in teaching creative design capability. Failure to attend to cultural values and practices underlying student attitude and behavior around creative problem-solving may lead to misunderstanding and misevaluation of their creative design activities. When East Asian students show not as much effort to solve design problems than American students, teachers should reflect how the design problems are framed through teaching and coaching narratives and group discussions. With the flourishment of global collaboration in various engineering classrooms and best educational practices being replicated across cultures, we have not seen curriculum interventions that originate from students' diverse cultural needs. When cultural differences are unknown or ignored, students may get culturally biased grades and undergo psychological difficulties. For instance, Japanese students coming to a U.S. university for a co-final presentation with their U.S. student partners may get ill-evaluated for a lack of articulation on how their ideas break through the status quo, which is considered desirable in Japan (preservation-orientation) but not necessarily so in the U.S. This is problematic given that student evaluation is less based on traditional exams of fundamental science knowledge, but rather increasingly subjected to culturally-shaped subjective experience.

We want to fight against the stereotype that East Asian students are less "liberated" and are thus less creative. The traditional Western notion of creativity falsely assumes social structural freedom and individual agency to be the prerequisite for creativity. Our research has broadened the behavioral and motivational spectrum of creativity.

Together, we call for engineering design educators and practitioners to explicitly incorporate cultural values into their design processes. And we encourage the use of diverse and inclusive framings of teaching materials and project challenges, so that students would not be differentially positioned and unfairly evaluated.

7.4. Limitation

The study could be improved in several ways. First, the current sampling was not ideal due to our limited access to representative groups of engineering students in both countries. Second, the Japanese sample has very few female students, which may reflect how low the female/male ratio is in Japan. A larger sample size could address the issue and make it possible to statistically examine the role of gender in the study. Third, the survey was designed not specifically for engineering students, although it worked fine, and many students reported they enjoyed the survey. The study result may illuminate more insights on engineering design problem-solving if the task was an engineering design problem. Future research should build upon the current work and address these limitations.

8. Conclusion

"Enable *change* in Japan through design and creativity", says the mission of IDEO Tokyo. Design Thinking programs in East Asian societies, such as provided by IDEO, are replete with goals and framings highlighting change. It reflects our lack of understanding and appreciation of cultural assumptions of designers in non-Western societies. In this paper, we conducted a survey study of engineering students in Japan and the U.S. about their preservation and change orientations during the process of creative ideation and validated our hypothesis. We have shown that students from different backgrounds could have very different cultural motivations associated with creative design. Japanese engineering students are more instigated by preservation-oriented problem statements and are less motivated by changing situations. We hope the current work would stimulate reflections on principles and practices of creative design that are widely applicable, as well as to uncover assumptions about design that are culturally specific.

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