Problem framing and cognitive style: Impacts on design ideation perceptions

Eli M. Silk, College of Engineering, University of Michigan, Ann Arbor, USA

Amy E. Rechkemmer, Department of Computer Science, University of Michigan, Ann Arbor, USA

Shanna R. Daly, Department of Mechanical Engineering, University of Michigan, Ann Arbor, USA

Kathryn W. Jablokow, School of Engineering Design and Department of Mechanical Engineering, Pennsylvania State University, USA

Seda McKilligan, Department of Industrial Design, Iowa State University, USA

Designers' engagement in ideation is impacted by their perceptions of the parameters of the design task. Whereas expert designers actively interrogate and reframe given problems, novice designers tend to solve them as given. We investigated novice designers' perceptions of their ideas relative to problem frames and their cognitive styles. We found that innovative styles and framings corresponded to higher perceptions of idea diversity and creativity, whereas adaptive framings corresponded to lower perceptions of idea creativity and perceptions of greater difficulty generating ideas. Novice designers may hold implicit theories of creativity that undervalue adaptive creativity. However, problem frames that misalign with a novice's preferred cognitive style can impact their ideation, and so hold promise for challenging their initial interpretations and approaches.

Keywords: creativity, conceptual design, design problems, framing, cognitive style

Considerable research has focused on approaches to support successful design ideation (e.g., Daly, Seifert, Yilmaz, & Gonzalez, 2016, Hernandez, Shah, & Smith, 2010; Linsey et al., 2011), so that designers achieve an ideal outcome of both breadth and depth of their ideas in their exploration of a solution space. Multiple ideation strategies and tools exist from which a designer could choose, and their choice depends on their perceptions of the goals of ideation in general and the goals of ideation in

Corresponding author:
Shanna R. Daly
srdaly@umich.edu

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the context of the design task in which they are engaged. For example, if a designer perceives a design task as requiring immediate practical solutions, she may not leverage strategies that promote "wild ideas." Or, if a designer thinks ideation requires creativity and feels his current ideas are not creative, he may choose an approach that facilitates creative thinking. Although there is notable research that focuses on the external evaluation of design idea characteristics (e.g., Daly et al., 2016; Linsey et al., 2011; Shah, Vargas Hernandez, & Smith, 2003), designers' own perceptions of their ideas may be a significant driver in choosing ideation approaches. Further, designers' approaches are likely compelled by their perceptions of the expectations for solutions set up in the description of the design problem and task.

Designers' perceptions of their ideas and approaches to ideation are linked to their cognitive preferences for problem solving, known as *cognitive style*. Cognitive style can be characterized in terms of the type and amount of structure a person prefers when solving problems, as described by Kirton's Adaption-Innovation cognitive style continuum (Kirton, 2011). In general, individuals who are more adaptive prefer more structure (with more of it consensually agreed), while more innovative individuals prefer less structure (with less concern about consensus). These differences produce distinctive patterns of behavior, both when working alone and in teams. In a design context, designers naturally interpret their ideas based on these cognitive preferences. For example, the same idea may be perceived as very elaborate by an innovator, who is less inclined to spend time fleshing out details, while it is perceived as not elaborate enough by an adaptor, who strives to articulate the details.

Designers' perceptions of their ideas and approaches to ideation are also likely to be influenced by their conceptions of idea generation, including how ideation should proceed and what ideation outcomes should look like. There are common biases that may influence what people consider to be a "good idea." For example, the ways people use the word "creative" colloquially are more in line with the innovative style of creativity from Adaption-Innovation Theory (Kirton, 2011), where ideas break from existing paradigms and are sometimes perceived as "bold" and "out of the box." Implicit theories of creativity held by laypeople (including students) are often not consistent with Kirton's descriptions of styles of creativity in A-I theory (Puccio & Chimento, 2001). Limited research has addressed how commonly-held theories and individual preferences may come into play when assessing one's own ideation outcomes.

In addition to a designer's cognitive style and perceptions of ideation, the way a problem is described and the information included within a problem statement—which constitute the "problem frame"—are compounding factors in designers' approaches to ideation and their ideation outcomes. The problem frame can facilitate a different perspective on a problem (Daly, McKilligan,

Studer, Murray, & Seifert, 2018; Murray, Studer, Daly, McKilligan, & Seifert, 2019; Silk, Daly, Jablokow, Yilmaz, & Rosenberg, 2014; Studer, Daly, McKilligan, & Seifert, 2018; Wright et al., 2015) and thus influence ideas generated and how ideation is approached. As designers construct a solution space based on their understanding of the problem (Payne, Bettman, & Johnson, 1992), changing problem frames can impact the design spaces they construct and the breadth of their exploration. While expert designers can and do reframe problems as part of their design processes (Crismond & Adams, 2012; Paton & Dorst, 2011), novice designers have been shown to treat design problems as straightforward and develop solutions for the given problem, rather than reframe it (Crismond & Adams, 2012). Additionally, while some research connects solutions to the ways the design problem is understood (Cross, 2004; Hey, 2008; Schön, 1984), much of this research has not translated to ideation approaches, as many approaches do not focus on ways perceptions of the problem or ideation itself may be altered to support broad and deep explorations of a solution space (Smith, 1998). Thus, there is an opportunity for problem framing to be used more intentionally in design work, particularly by novices.

In this study, we aimed to better understand relationships of problem framing and cognitive style to student designers' perceptions of their own idea generation outcomes—specifically creativity, diversity, and elaboration of their ideas, which are common ideation metrics (Dean, Hender, Rodgers, & Santanen, 2006; Kirton, 2011; Shah et al., 2003). We also aimed to understand how student designers' perceptions of their ideation approaches impacted the ease or difficulty with which they were able to generate ideas and the extent to which their perception of the problem frame led them to generate more familiar ideas versus new ideas. We gathered data on participants' cognitive styles through Kirton's Adaption-Innovation Inventory (Kirton, 1976, 2011), gathered ideas generated by participants with problems framed neutrally and then more adaptively or innovatively, and asked participants to evaluate their ideas and their ideation process. The outcomes of the study can be used to direct how ideation strategies are developed and taught, ultimately improving the ideation outcomes designers can yield.

1 Background

1.1 Cognitive style and ideation

Cognitive style is defined as a dimension of personality that reflects the strategic, stable, preferred way in which people respond to and seek to bring about change, including problem solving (Kirton, 2011). Of the many theoretical frameworks used to model cognitive diversity (e.g., Allinson & Hayes, 1996; Kirton, 2011; Messick, 1976; Sternberg & Grigorenko, 1997, 2001), Kirton's Adaption-Innovation (A-I) theory (Kirton, 2011) stands out in terms of its rigor in clearly explaining the complexity of cognitive style. In particular, the application of A-I theory among scholars investigating the impact of

cognitive style within engineering problem solving and creative behavior is growing (Buffinton, Jablokow, & Martin, 2002; DeFranco & Neill, 2011; Helm, Jablokow, Daly, Yilmaz, & Silk, 2016; Jablokow, Teerlink, Yilmaz, Daly, & Silk, 2015; Vercellone-Smith, Jablokow, & Friedel, 2012).

Kirton's Adaption-Innovation Theory distinguishes between cognitive level and cognitive style. *Cognitive style* reflects an individual's preference for structure in solving problems and exhibiting their innate creativity. In contrast, *cognitive level* is an individual's capacity for problem solving and creative behavior, as assessed through measures of both potential capacity (e.g., intelligence, aptitude, talent) and manifest capacity (e.g., knowledge, skills, expertise). Cognitive style can be reliably measured using Kirton's Adaption-Innovation Inventory or KAI® (Kirton, 1976, 2011). 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 ($SD = 17$) and an observed range of 43−149; lower scores correspond to more adaptive cognitive styles, while higher scores correspond to more innovative cognitive styles. Use of KAI to assess cognitive style is controlled through formal certification, which provides detailed instruction on how to determine whether an individual's KAI results are reliable; this supports its rigorous application in research.

Kirton's A-I theory is based on the underlying premise that all individuals are creative, but they have different preferred styles of problem-solving and creativity (Kirton, 2011). Some individuals (i.e., those whose cognitive style is more adaptive) prefer to generate more incremental ideas, while others (i.e., those whose cognitive style is more innovative) prefer to generate more radical ideas. Adaptive creativity leverages and refines existing structure in the generation and development of solutions. A person engaging in adaptive creativity is more likely to generate ideas that incrementally support and strengthen the prevailing paradigm, changing that paradigm through their use. In contrast, innovative creativity discards and deconstructs existing structure in the generation of solutions. A person engaging in innovative creativity is more likely to generate ideas that radically challenge and replace the prevailing paradigm, destabilizing the existing structure as a result. In their investigation of paradigm-relatedness as a metric for design solutions, (Silk, Daly, Jablokow, & McKilligan, 2019) described these two general directions for change as "paradigm preserving" (i.e., more incremental or adaptive creativity) and "paradigm modifying" (i.e., more radical or innovative creativity), respectively. Kirton (2011) and other scholars (Jablokow & Kirton, 2009; Sternberg, 2005; Sternberg, Kaufman, & Pretz, 2013) argue that all styles of creativity are equally valuable, although particular styles of creativity may have advantages in specific situations.

Despite this inclusive scholarly perspective, individuals tend to hold implicit views of creativity (Puccio & Chimento, 2001) that are influenced by the cultural attitudes, values, and biases that surround them (Ramos & Puccio,

2014) and which may lead to biased views about the value of creative outcomes. A common implicit view found by both Puccio and Chimento (2001) and Ramos and Puccio (2014) across different ethnic groups and countries is the belief that innovative people are more creative than their adaptive counterparts (using Kirton's terms). This bias was especially strong among those with a more innovative style (as measured by KAI). For example, a common notion of what is "novel" (often part of the definition of a creative outcome) may be skewed to align more with Kirton's innovative style of creativity (Litchfield, Gilson, & Gilson, 2015). Even A-I Theory's labeling of this type of creative person—"innovative"—aligns more with current colloquial definitions of creativity (although this was not always the case). Puccio and Chimento (2001) provide possible explanations for this bias, including innovation currently holding a higher status in society than adaption, and innovators being more likely to promote themselves as creative people to others than adaptors are. However, the extent to which this bias translates to the self-assessment of one's own ideas is unknown.

The diversity of an idea set and the elaboration of ideas are studied as the two other common ideation metrics (Dean et al., 2006; Kirton, 2011; Shah et al., 2003). The colloquial meaning for the "diversity" of an idea set may also stray from its scholarly definition using A-I Theory. According to A-I Theory, innovators are more likely to generate ideas that "jump around" within a solution space, while adaptors are more likely to dig deeply into one or more focused areas of that space (Kirton, 2011). Both approaches to exploration result in collections of different ideas. However, the colloquial definition of "diverse" tends to loosely emphasize the "distance" between ideas (Nelson, Wilson, Rosen, & Yen, 2009; Shah et al., 2003; Verhaegen, Vandevenne, Peeters, & Duflou, 2013), which aligns with Kirton's more innovative approach. Colloquial definitions of elaboration may present fewer tensions with A-I theory. Ideas generated by the more adaptive tend to be highly detailed and organized, while the more innovative pay less attention to detail (Kirton, 1976, 2011). However, *perceptions* of both the elaboration and the diversity of ideas have not been a common topic of study in the literature.

In our prior work, we examined working in a team as an ideation strategy (Jablokow et al., 2015). We compared perceptions of team members after generating ideas with others of similar and different cognitive styles and found that individuals of different cognitive styles evaluated the creativity, diversity, and elaboration of their design solutions differently. Additionally, the study found that the farther apart the cognitive styles of the student designers were, the more differently they assessed the extent of their contributions to

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the team-based design. This prior work suggests that perceptions of ideation outcomes may be influenced by a designer's cognitive style and that the impact of different ideation strategies may be seen as more positive or negative based on one's cognitive style. However, this potential relationship needs further examination.

1.2 Problem framing

The term "problem framing" represents differences in the ways problems are presented, including the articulation of constraints, types of goals, and task instructions (Frisch, 1993; Tversky & Kahneman, 1981). Changing the scope of a problem can impact the types of solutions generated. For example, Rietzschel, Nijstad, and Stroebe (2014) found that the very broad problem scope ("possible improvements in the education at the department of psychology") used in their experiment produced less original ideas than a narrower version of the scope ("possible improvements in the lectures at the department of psychology"). Dorst and Cross (2001) emphasized that surprise keeps a designer from routine behavior, whether the surprise is in the problem space or the solution space. In the problem space, design problem statements allow new frames of reference and descriptions of the design activity to emerge (Dorst, 2006). The specified goals of the problem statement also impact outcomes of ideation. For example, idea generation researchers have found an improvement in generating a greater quantity of ideas when including instructions for generating a specific number of ideas ("generate 30 ideas") versus a vague quantity goal ("generate as many ideas as you can") (Litchfield, 2009). A vague goal to "do your best" may produce less effective performance than a more specific and difficult goal, since it may be hard to understand what counts as successful in a more open-ended situation. Other goals that have been manipulated to prompt different kinds of solutions to the same problem include specifying that the solutions need to be "creative" (Shalley, 1991) or "novel" (Litchfield, Fan, & Brown, 2011).

While a problem can be reframed in multiple ways, individuals' interpretations of a framing can vary considerably. For example, a more informed design approach that differentiates expert behavior from novice design is to engage in active problem framing rather than simply problem solving (Crismond & Adams, 2012); novice designers may assume the problem is fixed as presented, while experts may question its assumptions (Harfield, 2007). "Discovery-oriented" behavior in designers is described as actively imposing one's own perspective on the problem in order to direct the search for a solution (Cross, 2004). Successful and experienced designers are proactive in problem framing and use those different frames to direct their search for possible

solutions. Schön (1987) described how designers frame a problematic design situation by setting its boundaries and selecting particular objects and relations for attention, and then using that frame to impose a coherence that guides their subsequent design activities. In the same way that a given framing can influence the way a solution space is bounded and explored, how designers frame a problem themselves can influence the kinds of solutions they consider. The process of intentionally altering the problem frame allows a designer to "see", "think", and "act" to create a novel standpoint from which a problem can be tackled (Dorst, 2011). Potentially, each novel view of the problem may lead to different types of solutions. A concern with novice designers is that they are likely to see a problem as given and to proceed too quickly to generating solutions from that initial understanding (Crismond & Adams, 2012). They are less likely to acknowledge their own implicit problem framing, nor to consider alternative understandings and approaches.

It is likely that the kinds of solutions considered by designers are impacted by both the way a problem is framed and the way each designer interprets that presentation and reframes it. Person-situation fit theory (Puccio, Talbot, & Joniak, 2000) suggests that individual factors and problem factors may work together to influence one's approach to idea generation in a particular problem. For example, O'Hara and Sternberg (2001) reviewed the literature on explicit instructions to be creative and suggested that there may be an interaction of goal criteria with participants' thinking styles. They described a situation in which a task had "neutral instructions" and so did not explicitly specify what types of ideas to generate. In this case, individuals may rely on their habitual strategies. On the other hand, explicit instructions may serve to "disambiguate" the situation, which may then enable individuals to break out of their habitual or dominant responses in favor of a strategy that is better suited to the particular situation.

Basic notions about the implications of cognitive style on individual performance have been labeled as the "matching hypothesis" in education and training literature (Cuevas, 2015; Hayes & Allinson, 1996; Pashler, McDaniel, Rohrer, & Bjork, 2009) and "person-environment fit theory" in business and management literature (Edwards, Cable, Williamson, Lambert, & Shipp, 2006; Puccio et al., 2000). Both the matching hypothesis and person-environment fit theory propose that an individual will have some real or perceived advantage when placed in a situation where prominent features of that situation closely align with relevant characteristics of their personal style. The converse is also implied—when there is a mismatch or misfit between the person and the environment, then the individual may experience some real or perceived disadvantage.

In the context of problem framing and idea generation, the implication of the matching hypothesis and person-environment fit theory for "person-problem

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gaps" (Jablokow & Booth, 2006) is that a designer may perceive their ideas as being easier to generate when they are placed in an ideation situation that encourages them to utilize their preferred problem-solving approach. Similarly, the designer would be likely to perceive their ideas as being more difficult to generate when placed in an ideation situation that discourages use of their preferred problem-solving approach or that encourages an alternative or non-preferred approach (i.e., coping behavior – see Kirton, 2011). However, recent theoretical and empirical research in cognitive styles has challenged these basic notions (Edwards et al., 2006; Kozhevnikov, Evans, & Kosslyn, 2014). For example, Zhang, Sternberg, and Fan (2013) studied the relationship between university students' preferred thinking styles and their preferred teaching approaches. They found that although some students do prefer a match between the two, many students explicitly seek out teachers that will either challenge or complement their own preferred style in some way.

Problems framed in ways that do not align with one's preferred framing may be well-received by some individuals; for others, problems that do align with one's preferred framing may be desired. Our prior research indicated that problem frames can be intentionally altered to guide designers in the generation of ideas outside of their preferred approaches (Silk et al., 2014; Silk et al., 2016; Wright et al., 2015). However, this work did not focus on how designers of different cognitive styles perceived the quality of the outcomes they developed with these new framings. Since perceptions of outcomes contribute to decisions to pursue particular approaches in the future—as evidenced by novice perceptions and practices engaging in design, and more specifically, a lack of recognition and exploration of problem statements and under-explored solution spaces in which they prematurely select ideas (Crismond & Adams, 2012)—it is important to understand if and how cognitive style is associated with personal idea assessments resulting from preference-aligned and mis-aligned interventions.

2 Research design

2.1 Research questions

The following research questions guided our study:

- *RQ1: What is the relationship between different cognitive styles and students' perceptions of their own ideation?*
- *RQ2: What is the relationship between different style-based problem framings and students' perceptions of their own ideation?*

To answer these research questions, we conducted an experiment that controlled for the types of problem frames that novice designers received and compared these problem frames with their cognitive styles and perceptions

of their ideation outcomes. We analyzed these data quantitatively to identify significant patterns in relationships between problem frames, cognitive style, and perceptions of ideation outcomes.

2.2 Participants

Participants were recruited from eight engineering and industrial design courses at three Midwestern universities. They included high school students participating in a pre-engineering program, first-year undergraduates in an introduction to engineering course, sophomore-level students in a mechanical engineering design course, upper level undergraduate and graduate students in an industrial design course, and upper level undergraduate and graduate students in a mechanical engineering design course. While the participants represented some range of ability levels and experience with engineering and design, we considered the participants to be more toward the "novice" side of a novice-expert design continuum, as participants had not begun their careers where they engaged in solving real design problems on a regular basis. Novice designer perspectives were of particular interest as research shows they are more likely to take a design problem as given (Crismond & Adams, 2012), thus allowing us to investigate how problems framed and perceived in particular ways can impact their initial ideation approaches and outcomes.

A total of 102 participants had complete and reliable data and were included in this study. Initially, 194 participants consented to participate in the study. However, 16 participants did not fully complete the survey for recording perceptions of their ideation outcomes, and KAI scores were not reliable for an additional 76 participants, so those participants were excluded from the analyses. Of the included participants, 19 were high school students, 73 were undergraduate students, and 10 were graduate students. Eighty-five of the participants identified themselves as male (83.3%) and 17 as female (16.7%). In terms of race, 57.8% of participants identified as Caucasian, 20.6% identified as Asian, 8.8% identified as African American, and 12.8% reported identifying with other or multiple races.

In implementing the research design, participants were randomly assigned to one of two problem framing groups (Adaptive Framing or Innovative Framing). While the KAI is a continuum, participants were also classified into one of two cognitive style groups (KAI total score for Adaptors ≤ 95 and Innovators >95) in order to support the experimental design and analysis, consistent with practices of other scholars using KAI in research studies (Kirton, Bailey, & Glendinning, 1991). Table 1 reports the number of participants and the KAI total score mean and standard deviation for each group. Because of the participant exclusions and random variation in the distribution

Table 1 Numbers of participants and KAI descriptive statistics for the study groups

	Adaptors		*Innovators*		*Total*	
	N	M (SD)	*n*	M (SD)	*n*	M (SD)
Framing						
Adaptive	20	84.8 (7.6)	27	105.5 (7.6)	47	96.7 (12.8)
Innovative	32	83.3 (9.5)	23	104.0 (7.0)	55	91.9 (13.3)
Total	52	83.9 (8.8)	50	104.8 (7.3)	102	94.1 (13.2)

of KAI scores, the numbers of participants were not perfectly balanced. Nevertheless, as expected by the research design, there was a large and significant KAI gap between the mean scores of the Adaptor and Innovator cognitive style groups, $t(100) = 13.03$, $p < .001$, Cohen's $d = 2.59$, but not between the randomly-assigned Adaptive Framing and Innovative Framing groups, $t(100) = 1.81$, $p = .07$, Cohen's $d = 0.36$.

2.3 Experimental procedure

Each participant completed two sequential ideation sessions. Although the sessions were conducted in a group setting, all of the activities were completed individually. First, participants were given a brief introduction to the role of idea generation in the design process, and then each student was given a neutrally-framed design problem statement. The students had 20 minutes to individually generate ideas for this baseline ideation session. They were instructed to record each new idea on a separate page using a structured idea sheet with designated space for visual sketches and for verbal descriptions. Following this first ideation session, participants completed the reflection survey to record their perceptions of the baseline ideation session.

Next, the students participated in an intervention ideation session. A brief presentation was given about the importance of generating ideas in a new context. Participants randomly assigned to the Adaptive Framing condition received an adaptively framed design problem, and those randomly assigned to the Innovative Framing condition received an innovatively framed design problem. Participants were not informed explicitly that the new problem statement had a specific type of framing. While participants were not forbidden from reframing the problem, the choice not to encourage participants to reframe the problem mimicked design settings where a framing has been set, whether through multiple iterations or perceived as set by the designers from a given problem. Based on common novice design behaviors, we did not expect participants to intentionally reframe the problem and none of our data showed an explicit rewriting of the problem statement by any participant.

With this new problem and framing, students were again given 20 minutes to generate ideas and then completed a second reflection survey to record their

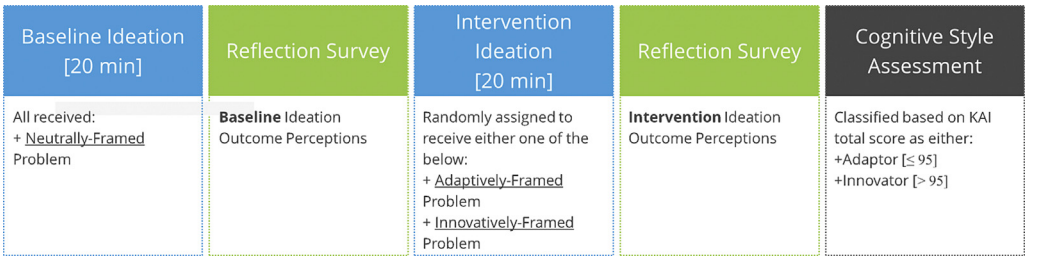

Figure 1 Study procedure

perceptions of the intervention ideation session. Finally, each participant completed the KAI (cognitive style) inventory. Figure 1 illustrates this study procedure.

2.4 Materials

2.4.1 Design problem statements

The problem statements used in the study were developed from four problem contexts—all from prior work on problem framing: (1) Public Place Belongings Securer ["Belongings"], (2) One-Hand Opener for Lidded Food Containers ["Lids"], (3) Remote Village Rainwater Catcher ["Rainwater"], and (4) Low-Skill Snow Transporter ["Snow"] (Silk et al., 2014). For each context, we developed three problem statements, guided by A-I Theory (Kirton, 2011): (A) Neutral Framing; (B) Adaptive Framing; and (C) Innovative Framing. The neutral framing included a description of the design scenario that did not favor one cognitive style approach over any other, so it could serve as a baseline for how an individual naturally preferred to approach ideation. The two cognitive style-based (non-neutral) framings were intended to encourage individuals to generate either more adaptive or more innovative ideas, respectively. See Appendix A for an example of the Lids problem context framed into neutral, adaptive, and innovative problem statements. The language in the problem statements was chosen intentionally to be open to a diversity of interpretations of what constituted more adaptive and more innovative ideas. For example, the statements encouraged the designers to think in terms of both "designs" and "ways of approaching the problem". For further details on the construction of the problem statements see Silk et al. (2014). Participants were assigned to a different problem context for their baseline ideation as compared to their intervention ideation, and the problem contexts were counterbalanced across participants and the two sessions.

2.4.2 Reflection survey

A reflection survey was used to capture how participants perceived their ideation outcomes after each ideation session. Participants evaluated the

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creativity, elaboration, and diversity of their ideas, as well as the ease of generating ideas and whether each problem frame encouraged "familiar" or "new" ideas. Each survey item was presented on a 7-point Likert-type scale. For example, participants were asked, "On a scale from 1 to 7, how creative do you feel that your ideas were?", and descriptive anchors were provided at 1 (Not creative), 4 (Neutral), and 7 (Very creative). The reflection survey items are included in Appendix B.

2.4.3 Cognitive style inventory

Cognitive style was assessed via the Kirton Adaption–Innovation inventory or KAI® (Kirton, 2011). The KAI consists of 32 items in which participants indicate the level of difficulty required for them to present themselves in a certain way consistently, over a long period of time. For example, one item is "A person who is a steady plodder", and the participants respond on a continuous scale from "Very Hard" to "Very Easy".

2.5 Data analysis

The primary dependent variables in this study were participants' perceptions of the ideas they generated in the idea generation sessions (baseline and intervention). The ideation session (baseline vs. intervention) was a within-subjects independent variable; the type of framing (Adaptive vs. Innovative) participants received was a between-subjects independent variable; and participants' cognitive style (Adaptor vs. Innovator) was a between-subjects independent variable.

The dichotomous cognitive style grouping facilitated contrasting the two poles of cognitive style as a way to explore overall differences between more adaptive and more innovative individuals. Future studies could utilize larger sample sizes to investigate subtler distinctions along the KAI continuum. To further consider this possibility, we also conducted our analyses with three KAI groups—divided by KAI total score into Adaptors ($\leq$90), Mid-Range ($>$90 and $\leq$100), or Innovators ($>$100), similar to the approach of Bobic, Davis, and Cunningham (1999). This three-group analysis resulted in the same overall pattern of findings as with two KAI groups. Therefore, for clarity in reporting the findings and due to space limitations, only the analyses with two cognitive style groups will be reported in this paper.

To answer Research Question 1 (What is the relationship between different cognitive styles and students' perceptions of their own ideation?), unpaired *t*-tests contrasting perceptions of the baseline ideation between Adaptors and Innovators were conducted for each of the perception outcomes (5 total tests). To answer Research Question 2 (What is the relationship between

different style-based problem framings and students' perceptions of their own ideation?) separately for each of the framing conditions, paired *t*-tests contrasting perceptions in the baseline ideation with perceptions in the intervention ideation were conducted for each of the perception outcomes within each cognitive style (20 total tests). Significance was evaluated for each test at a level of $p < .05$. As this was exploratory research, we did not correct for multiple comparisons in order to minimize the risk of failing to detect real effects. Cohen's *d* effect sizes were calculated for the significant contrasts only. All inferential statistics were conducted using R statistical software.

3 Findings

3.1 Cognitive style

RQ1: What is the relationship between different cognitive styles and students' perceptions of their own ideation?

To answer this research question, only the data from the baseline ideation sessions were analyzed. Our results show that Innovators tended to perceive the ideas they generated in their baseline ideation to be more diverse compared to Adaptors' perceptions of their baseline ideas. Significant differences between cognitive style groups were not observed when considering participants' perceptions of creativity, elaboration, ease, or the familiarity of ideas that the written description encouraged. The results are reported in Table 2.

3.2 Problem framing

RQ2: What is the relationship between different style-based problem framings and students' perceptions of their own ideation?

In reporting our findings for this research question, we first present trends based on problem framing independent of cognitive style, and then results for each combination of cognitive style and problem frame are reported. Experimental conditions in which the problem framing and cognitive style were matched (adaptors with an adaptively framed problem; innovators with an innovatively-framed problem) were contrasted with conditions in which there was a mismatch between problem framing and cognitive style.

3.2.1 Framed problems

Independent of students' cognitive style, our results show that participants who received the Innovative Framing perceived their ideation as more creative in the intervention ideation compared to the baseline ideation; they also perceived that the written description encouraged them to generate less familiar ideas. Participants in the Adaptive Framing group perceived that it was more difficult to generate ideas in the intervention ideation compared to the baseline ideation. Significant differences were not observed for either

Table 2 Ideation perceptions by cognitive style for baseline ideation only

Perception	*Adaptors* M (SD)	*Innovators* M (SD)	t[a]	p	*Cohen's* d
Creativity	4.19 (1.17)	4.62 (1.34)	1.72	0.09	
Diversity	3.92 (1.43)	4.58 (1.50)	2.27	0.03[b]	0.45
Elaboration	4.08 (1.28)	3.92 (1.35)	−0.60	0.55	
Ease	4.33 (1.62)	4.28 (1.49)	−0.15	0.88	
Written description encouraged familiar ideas	4.44 (1.30)	4.32 (1.32)	−0.47	0.64	

[a] Degrees of freedom is 100 for each test.
[b] $p < .05$.

Table 3 Ideation perceptions from baseline and intervention by framing type

Perception	*Baseline* M (SD)	*Intervention* M (SD)	t[a]	p	*Cohen's* d
Creativity					
Adaptive	4.62 (1.28)	4.04 (1.57)	−1.85	0.07	
Innovative	4.22 (1.24)	4.91 (1.49)	2.63	0.01[b]	0.35
Diversity					
Adaptive	4.47 (1.44)	4.09 (1.70)	−1.28	0.21	
Innovative	4.05 (1.52)	4.31 (1.70)	0.82	0.42	
Elaboration					
Adaptive	4.15 (1.38)	3.91 (1.44)	−0.79	0.43	
Innovative	3.87 (1.25)	3.98 (1.60)	0.49	0.62	
Ease					
Adaptive	4.43 (1.54)	3.77 (1.54)	−2.13	0.04[b]	−0.31
Innovative	4.20 (1.56)	4.13 (1.68)	−0.27	0.79	
Written description encouraged familiar ideas					
Adaptive	4.19 (1.15)	4.55 (1.46)	1.19	0.24	
Innovative	4.55 (1.41)	3.47 (1.78)	−4.20	<0.01[b]	−0.57

[a] Degrees of freedom is 46 for the Adaptive Framing group and 54 for the Innovative Framing group.
[b] $p < .05$.

framing group when considering participants' perceptions of diversity or elaboration of their ideas. These results are reported in Table 3.

3.2.2 *Adaptors and framed problems*

For Adaptors assigned an Adaptive Framing—i.e., a framing that matches their cognitive style—no significant differences were observed in any of the ideation perceptions between the baseline and intervention sessions. However, two significant differences were observed when Adaptors received the Innovative Framing—i.e., a framing that does not match with their cognitive style. First, Adaptors tended to perceive their ideation as more creative in an innovative framing ideation as compared to the baseline ideation. Second, Adaptors also perceived that the written description of the innovative framing encouraged them to generate less familiar ideas in the intervention ideation compared

Table 4 Ideation perceptions from baseline and intervention by framing type for the adaptors only

Perception	*Baseline*	*Intervention*	t[a]	p	*Cohen's* d
	M (SD)	M (SD)			
Creativity					
Adaptive	4.45 (1.19)	4.30 (1.78)	−0.28	0.78	
Innovative	4.03 (1.15)	5.06 (1.32)	3.11	<0.01[b]	0.55
Diversity					
Adaptive	4.30 (1.59)	3.90 (1.52)	−0.81	0.43	
Innovative	3.69 (1.28)	4.25 (1.59)	1.58	0.12	
Elaboration					
Adaptive	4.35 (1.39)	3.90 (1.71)	−0.91	0.37	
Innovative	3.91 (1.20)	4.00 (1.44)	0.39	0.70	
Ease					
Adaptive	4.45 (1.54)	4.05 (1.39)	−0.85	0.41	
Innovative	4.25 (1.68)	4.34 (1.52)	0.26	0.80	
Written description encouraged familiar ideas					
Adaptive	4.40 (0.99)	4.70 (1.03)	0.83	0.42	
Innovative	4.47 (1.48)	3.41 (1.92)	−3.03	<0.01[b]	−0.53

[a] Degrees of freedom is 19 for the Adaptive Framing group and 31 for the Innovative Framing group.
[b] $p < .05$.

to the baseline ideation. There were no significant differences for Adaptors for diversity or elaboration of ideas or ease of ideation between the neutral and the innovatively framed session. These results are reported in Table 4.

3.2.3 *Innovators and framed problems*

For Innovators assigned the Adaptive Framing—i.e., a framing that does not match with their cognitive style—two significant differences were observed. First, Innovators tended to perceive their ideation as less creative in an adaptive framing ideation as compared to the baseline ideation. Second, Innovators also perceived that it was more difficult to generate ideas in an adaptive framing ideation compared to the baseline ideation. One significant difference was observed when Innovators received the Innovative Framing—i.e., a framing that matches with their cognitive style. These Innovators tended to perceive that the written description encouraged them to generate less familiar ideas in an innovative framing ideation compared to the baseline ideation. This change in perception about the written description of the problem aligns with the observed change in perceptions for the Adaptors who also received the Innovative Framing (see the previous section). The results for these situations are reported in Table 5.

Figure 2 illustrates selected findings relating problem framing with cognitive style. The figure is focused only on the participants' perceptions of the creativity of their ideas, as there was a significant effect observed from the baseline to intervention ideation for both cognitive style groups. The figure highlights

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Table 5 Ideation perceptions from baseline and intervention by framing type for the Innovators only

Perception	*Baseline* M (SD)	*Intervention* M (SD)	t[a]	p	*Cohen's* d
Creativity					
Adaptive	4.74 (1.35)	3.85 (1.41)	−2.45	0.02[b]	−0.47
Innovative	4.48 (1.34)	4.70 (1.72)	0.52	0.61	
Diversity					
Adaptive	4.59 (1.34)	4.22 (1.85)	−0.98	0.34	
Innovative	4.57 (1.70)	4.39 (1.88)	−0.31	0.76	
Elaboration					
Adaptive	4.00 (1.39)	3.93 (1.24)	−0.20	0.84	
Innovative	3.83 (1.34)	3.96 (1.85)	0.32	0.76	
Ease					
Adaptive	4.41 (1.58)	3.56 (1.63)	−2.07	0.05[b]	−0.40
Innovative	4.13 (1.39)	3.83 (1.87)	−0.75	0.46	
Written description encouraged familiar ideas					
Adaptive	4.04 (1.26)	4.44 (1.72)	0.89	0.38	
Innovative	4.65 (1.34)	3.57 (1.62)	−2.89	<0.01[b]	−0.60

[a] Degrees of freedom is 26 for the Adaptive Framing group and 22 for the Innovative Framing group.
[b] $p < .05$.

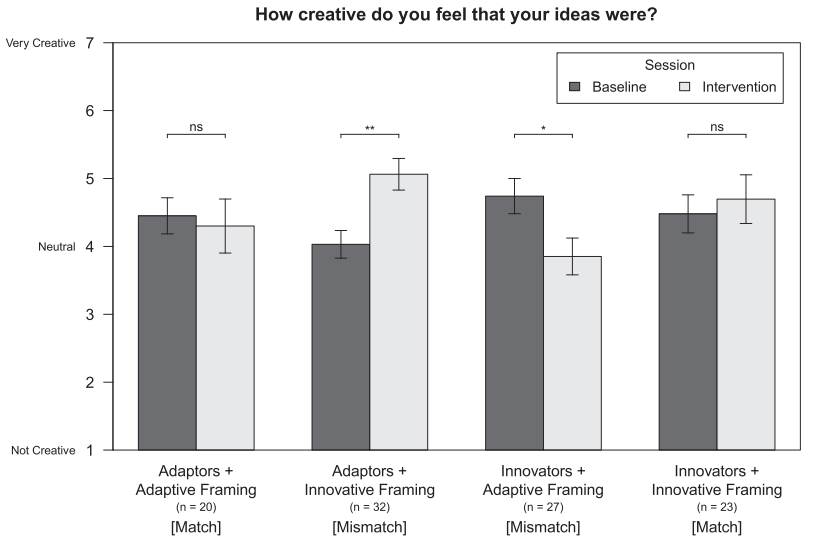

Figure 2 Perception of idea creativity generated in the baseline and intervention ideation sessions, respectively, for the two problem framings, separated by cognitive style: Adaptors (left) and Innovators (right)

how *mismatches (in style) impacted perceptions to a greater extent than matches*, as the effect in perception was only observed when Adaptors were assigned the Innovative Framing and when Innovators were assigned the Adaptive Framing. In addition, the effects of the mismatches were in opposite

directions. That is, relative to their baseline ideation perceptions, Adaptors perceived an increase in the creativity of their ideas when ideating with an innovatively framed problem, whereas Innovators perceived a decrease in the creativity of their ideas when ideating with an adaptively framed problem.

4 *Discussion*

With regard to perceptions of creativity in the baseline ideation session, we did not observe a significant difference between the participants who were classified as Adaptors and the participants who were classified as Innovators. With the framing intervention, the Adaptors with an Innovative Framing tended to perceive their ideation as more creative in the intervention ideation as compared to the baseline, whereas Innovators using the Adaptive Framing tended to perceive their ideation as less creative. From these results, it appears that the common culturally-related perception of creativity that associates adaptive ideas with a lower level of creativity and innovative ideas with a higher level of creativity (Puccio & Chimento, 2001) had a noticeable effect for the novice designers in our study. This perception is not consistent with the current scholarly cognition literature (e.g., Sternberg, 2005; Sternberg et al., 2013), including Kirton's Adaption-Innovation Theory, which served as a theoretical framework for the study design (Jablokow & Kirton, 2009; Puccio, Treffinger, & Talbot, 1995; Talbot, 1997). The results of the present study appear to confirm a cultural bias of novice designers in our study toward innovative types of creativity, as noted by Kirton (2011). The most direct evidence supporting the existence of the bias was that, when given an innovative problem framing, participants' perceptions of the creativity of their ideas increased relative to their perceptions in the neutral baseline problem framing. The direct evidence linking innovative framing with higher creativity perceptions would be further supported if the converse were also true—i.e., that use of an adaptive framing resulted in lower creativity perceptions. Interestingly, while the difference in participants' perceptions of the creativity of their ideas when using a neutral baseline problem framing and an adaptive problem framing was not statistically significant, the decrease (from neutral to adaptive framing) approached significance ($p = .07$; Table 3).

One explanation consistent with these results is that the innovative-creativity bias exists, but that the impact of the bias is not large. More power to observe the impact would be necessary to test this explanation, and so, a follow-up study with a larger sample size of participants would be warranted. A related possibility is that there is some asymmetry in the innovative-creativity bias. Similar to how prospect theory in decision-making has found that people weigh the impact of potential losses more heavily than the impact of potential gains (Tversky & Kahneman, 1981), it could be that the impact of a press for innovativeness has a larger impact on perceptions of creativity than a press for adaptiveness. Additional evidence from the current study that supports this

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potential asymmetry was that participants were more likely to perceive that the innovative framing explicitly encouraged the generation of new ideas relative to the neutral framing; this was true for both the Adaptors and the Innovators. However, the converse perception was not observed—i.e., participants were *not* more likely to perceive that the adaptive framing explicitly encouraged the generation of more familiar ideas relative to the neutral framing. It may be that the adaptive framing embedded within the problem statement was not explicit enough for participants to notice; future research might try to amplify the explicitness of the problem framings to test whether this asymmetry continues.

If the innovative-creativity bias exists, even if just for novice designers, then the popular notions of what constitutes creative ideation are in direct opposition to the work of Kirton (Jablokow & Kirton, 2009; Kirton, 2011) and others (Jablokow, Vercellone-Smith, & Richmond, 2009; Litchfield et al., 2015; Sternberg, 2005; Sternberg et al., 2013), all of which recognize that both adaptive and innovative creativity exist and are equally valuable in general. Not only does this bias devalue the creativity of adaptive ideas, it also devalues the creative potential of adaptive individuals. A step toward encouraging novice designers to generate a more expansive range of ideas involves changing the perception of adaptive ideas to having as great a potential for creative impact as innovative ideas.

Our findings showed that participants with a more adaptive cognitive style perceived their baseline neutral ideas to be less diverse compared to the perceptions of participants with a more innovative cognitive style. It is notable that this significant difference between Adaptors' and Innovators' diversity perceptions was observed when considering their relationship with cognitive style alone, but no differences in diversity perceptions were observed comparing the baseline and intervention sessions. This finding suggests that, unlike perceptions of creativity, novice designer diversity perceptions may be less influenced by the adaptive or innovative framing of a problem. One explanation of the cognitive style differences in diversity perceptions could be that the innovative-creativity bias of novices seen in our participants also extends to beliefs about diversity in ideation. Adaptive thinking includes building on and refining existing ideas, as well as the addition of constraints that narrow the range of ideas that are considered acceptable. Thus, more adaptive ideation may result in adaptors perceiving that they are working within a smaller solution space. Participants adopting more innovative ideation approaches may view fewer constraints as providing them with the latitude to consider ideas they may have previously thought to be unacceptable. The additional perceived constraints in an adaptively framed problem are also consistent

with our finding that participants perceived generating ideas with an adaptively framed problem as being more difficult than with a neutrally framed problem. However, this explanation would also predict that participants given an adaptively framed problem would perceive their ideas to be less diverse, but we did not observe differences in participants' perceptions of the diversity of their ideas in either problem framing. As a result, these explanations are speculative and would benefit from future studies that may more directly observe the ideation processes in which participants engage.

Another possibility is that we did not observe differences in perceptions of diversity because perceptions of ideation diversity are inherently more complex than other ideation metrics, which is consistent with other measures of ideation diversity (Nelson et al., 2009; Shah et al., 2003; Verhaegen et al., 2013). The participants in our study were students with a wide range of experiences with design, but still considered to be on the novice end of design expertise. As a result, idea diversity may be a construct with which these participants were not readily familiar, and so they may have had trouble evaluating it. Furthermore, participants may have evaluated diversity within the limited problem space from which they were working rather than more globally, as could be done by an external rater. Another example of the inherent complexity of diversity as an ideation outcome measure is that diversity, more so than other ideation outcomes, is strongly related to the *quantity* of ideas that are generated (Daly et al., 2016). Participants who generated a greater number of ideas may have also been likely to perceive their ideas as being more diverse, but the number of ideas generated by each participant was not considered in the current study. In future studies, accounting for or controlling for idea quantity may be a way to explore diversity perceptions further.

No differences were observed in participants' evaluation of the elaboration of their ideas between more adaptive and more innovative cognitive styles or in either problem framing relative to the neutral ideation session. While A-I theory predicts differences in actual elaboration of ideas (Kirton, 2011), novice designers who are either Adaptors or Innovators may perceive elaboration relative to their own standards of what is elaborate, holding conceptions of sufficient elaboration related to their cognitive styles. Another explanation is that the structure of the ideation sessions minimized the impact of problem framing on elaboration. The participants did not get much time to develop their ideas, and so it is possible that with more time, the different framings might have encouraged more or less elaboration that could have differentiated potential impacts of cognitive style and problem framing.

Innovators using the Adaptive Framing tended to perceive that it was more difficult to generate ideas in the intervention ideation as compared to the baseline ideation. We predicted that participants would perceive an advantage to their

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ideation process when operating in an environment that matched their respective cognitive styles and would perceive a disadvantage when operating in an environment that was mismatched with their cognitive styles, grounded in person-environment fit theory (Edwards et al., 2006; Puccio et al., 2000). In this case, we hypothesized that the perceived advantages and disadvantages would be observed primarily in perceptions of task difficulty, however the results provided only limited support for that conjecture. In particular, the only significant impact observed was that the Innovators perceived that generating ideas was more difficult in the adaptive framing compared to the neutral framing. This result was consistent with the facilitative-matching hypothesis in that the mismatch of an innovative cognitive style with an adaptive framing led to greater perceived difficulty. However, no other significant differences were observed, and so there was no corresponding impact of a mismatch for the Adaptors working with an innovative framing. There were also no observed facilitative impacts when problem framing and cognitive style were matched. Therefore, if there is an impact of matching at all in an ideation context, the results from this study suggest the facilitative advantages of matching a cognitive style with a problem framing for novice designers may be minimal. On the other hand, consistent with the asymmetric impacts discussed relative to the innovative-creativity bias, the results do suggest that it is useful to think of matching and mismatching separately. That is, although there may not be facilitative impacts of matching, there may be other negative impacts that result from *mismatches* between the person and the problem framing. With the framing intervention, both Adaptors and Innovators with an Innovative Framing tended to perceive that the written description encouraged them to generate less familiar ideas in the intervention ideation as compared to the baseline. This finding is in alignment with how they perceived creativity of their outcomes – the less familiar, the more creative.

4.1 Limitations

The current study examined only participants' perceptions of their ideation. Thus, the results presented here cannot confirm whether the observed relationships are consistent between perceptions and external raters' evaluation of ideas. It is possible that participants perceive impacts that are not manifested in their actual ideas, and it is also possible that there are impacts that are present in their ideas, but of which participants are not consciously aware (Pretz & McCollum, 2014). For example, individuals often perceive a benefit to ideating in groups, but that perception has typically been found to be an overestimate compared to their actual effectiveness when using more objective measures of their performance (Mullen, Johnson, & Salas, 1991; Paulus, 2000; Paulus, Larey, & Ortega, 1995; Paulus & Yang, 2000). In addition, even experienced designers are not readily aware when situational factors hinder their performance, such as being given common example solutions that often lead to greater design fixation (Linsey et al., 2010). Future research should consider

relationships of cognitive style and problem framing with external metrics of ideation outcomes.

Another limitation of the work is the experimental context of the study. On the one hand, a more tightly controlled experimental manipulation—such as when experimenters provide carefully crafted solutions as stimuli and then investigate participants' perceptions of those solutions (e.g., Mugge & Dahl, 2013)—would enable us to better isolate particular features of the ideation products that influence those outcome perceptions. However, we were specifically interested in understanding the impact framing could have on novice designers' own ideas, thus such tight control was not possible. On the other hand, richer qualitative observations of participants engaging in authentic ideation tasks might enable a more differentiated assessment of various cognitive styles within the adaptor/innovator dichotomy (e.g., Elsbach & Flynn, 2013). In that case, it would be challenging to control when and how the different problem framings were introduced during ideation. We do not know how novice designers would engage in problems in a work or course setting, when the stakes and contextual factors vary. An authentic context would also be more appropriate in determining the value of particular ideas. The focus of this work was not to claim ideas of a more radical or innovative nature were better or worse, but rather to explore how types of ideas might be prompted through problem frames, ultimately to support novice designers in their ability to diversify the ideas they consider. Diversity is a goal of idea generation, where the value is not placed on a particular idea, but rather the value lies in the ability to divergently explore possibilities before developing and evaluating them.

An additional limitation is that cognitive style, as measured by the Kirton Adaption-Innovation Inventory (KAI), is a continuous variable rather than a categorical variable, making the notion of dividing participants into two categories for the purpose of our analysis somewhat artificial. With the current cutoff in KAI total scores between categories set at 95 (as noted earlier), a person with a KAI score of 94 would be considered just as adaptive as a person with a KAI score of 60 in our calculations; this is not accurate, as the just-noticeable-difference between individual KAI scores is 10 points. One way of attempting to mitigate this effect was separating the participants into three KAI groups (see Section 2.5 above), but this approach does not entirely eliminate the problem. Splitting the participants into more categories also causes the issue of smaller sample sizes to arise. Another means of analysis that was not used in this study that could account for KAI as a continuous predictor variable would be a regression analysis; future studies will explore this approach with a larger sample. The effect sizes of the observed relationships in the current study were of moderate size (Cohen's d values ranging from 0.31 to 0.60). Given the moderate effect sizes, it may be that larger sample sizes are needed to reliably detect differences between cognitive style groups, between problem framings, and in the interactions between these factors. Further, because a large number of contrasts was tested in the analysis, there was a possibility of observing some statistically significant differences by chance alone.

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As this work was exploratory research, we did not correct for multiple comparisons in order to minimize the risk of failing to detect real effects. However, future confirmatory research would be needed to replicate the results and to test whether similar results hold under related experimental conditions.

4.2 Implications for education and practice

The results of this study can inform the recommendation and development of idea generation strategies and how these strategies are taught to others, particularly novice designers, as well as other designers who could benefit from more explicit awareness of problem reframing and the impact of that reframing. Specifically, instructors and authors of design guidebooks can be more explicit about strategies that promote the production of so-called "creative" ideas by being more precise in their description about styles of creativity and acknowledging the value of all types of creativity. Instructors can help novice designers to adjust their expectations of what successful design looks like and the value of both adaptively creative and innovatively creative ideas. Further, for ideation strategies that aim to support designers in achieving specific types of idea exploration (i.e., a certain type of diversity or creativity) or a particular degree of elaboration, design instructors and managers can clarify these outcomes and provide examples to support designers in achieving the intended goals.

Additionally, this work can support instructors and managers in recognizing the impact of the problems frames that they give or approve. Their role is not to do the problem framing themselves, but to empower novices to strategically reframe and recognize the impact of their own problem frame choices and interpretations. Also, instructors can be more aware that if they have expectations of certain types of solutions, their framing could have an impact on their students achieving these goals as they generate and develop design ideas.

The design education community (both instructors and researchers) could also be more explicit about the variety of definitions and perceptions of ideation outcomes. A lack of experience or instruction in exploration of problem and solution spaces likely contributes to novices under-exploring spaces in their design practices (Crismond & Adams, 2012). Thus, a clearer articulation of the value of different types of ideation outcomes can support novice designers (and others) in their own confidence, as well as help them identify more clearly how they can grow in their ideation skills. Novice designers can be strategic in what Kirton (2011) calls "coping behavior," recognizing their own natural ideation tendencies and intentionally leveraging strategies that allow them to generate ideas that stretch beyond those natural tendencies. With regards to problem framing, mismatching the frame with cognitive style could be used, intentionally, to help novices learn how to shift from their natural tendencies more readily. Mismatching may have more benefits in pushing novices to do

something that is different from their normal approach than matching would have in facilitating someone to do better with their normal approach.

This work also points to an important question in the design community: What "counts" as good idea generation outcomes? The research community cites creativity, diversity, and elaboration as three key outcome measures (Shah et al., 2003), but it has minimally acknowledged the variation in types of creativity and diversity, as well as what levels of elaboration are ideal in idea generation.

5 Conclusions

This study focused on how students perceive their own ideation outcomes, as these perceptions may influence the ways students engage in ideation. Our analyses revealed how a designer's individual cognitive style and colloquial definitions of design outcomes influence their perceptions of their design outcome. Additionally, the study highlighted how different cognitive styles have the potential to influence the way a problem is framed and interpreted, which is then reflected in students' perception of the types of ideas they created. The results of this work can guide design pedagogy, training, and the development of tools to support successful design idea generation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Design Problem Statements

The neutrally-framed design problem statement for the *Lids* problem context (Lemons, Carberry, Swan, Jarvin, & Rogers, 2010; Silk, Daly, Jablokow, Yilmaz, & Rosenberg, 2014):

	***Lids* Neutrally Framed**
Context	*One-Hand Opener for Lidded Food Containers* The local rehabilitation center helps to treat thousands of stroke patients each year. Many individuals who have had a stroke are unable to perform bilateral tasks, meaning they have limited or no use of one upper extremity (arm/shoulder). A common issue the hospital has observed with their stroke patients is in their ability to open jars and other lidded food containers. The ability to open lidded food containers is particularly important for patients who are living on their own, in which case they often don't have help around for even basic tasks. A solution to helping them open lidded food containers with one hand would go along way in helping the patients to maintain their independence.
Need	Design a way for individuals who have limited or no use of one upper extremity to open a lidded food container with one hand.

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Goals	Develop solutions for this problem. Be sure to write each solution on a different piece of paper, and use drawings to sketch your ideas. It's important that you do your best and continue working for the full time of the activity.

The adaptively- and innovatively-framed design problem statements for the *Lids* problem context:

***Lids* Adaptively Framed**		***Lids* Innovatively Framed**
One-Hand Opener for Lidded Food Containers		*One-Hand Opener for Lidded Food Containers*
The local rehabilitation center helps to treat thousands of stroke patients each year. Many individuals who have had a stroke are unable to perform bilateral tasks, meaning they have limited or no use of one upper extremity (arm/shoulder). A common issue the hospital has observed with their stroke patients is in their ability to open jars and other lidded food containers. The ability to open lidded food containers is particularly important for patients who are living on their own, in which case they often don't have help around for even basic tasks. A solution to helping them open lidded food containers with one hand would go along way in helping the patients to maintain their independence.	**Context** Same as neutrally-framed version	The local rehabilitation center helps to treat thousands of stroke patients each year. Many individuals who have had a stroke are unable to perform bilateral tasks, meaning they have limited or no use of one upper extremity (arm/shoulder). A common issue the hospital has observed with their stroke patients is in their ability to open jars and other lidded food containers. The ability to open lidded food containers is particularly important for patients who are living on their own, in which case they often don't have help around for even basic tasks. A solution to helping them open lidded food containers with one hand would go along way in helping the patients to maintain their independence.
Design a way for individuals who have limited or no use of one upper extremity to open a lidded food container with one hand. **Your solutions should focus on improving existing designs or adapting familiar ways of approaching the problem or similar problems.** Consider constraints such as cost and size in your solutions, since patients are often on very tight budgets and generally want items that aren't going to take up much space in their kitchens. Also think about how the solution is powered, since the solution should be able to work manually rather than using electricity, which costs money and is not always reliable.	**Need** Added criteria and constraints	Design a way for individuals who have limited or no use of one upper extremity to open a lidded food container with one hand. **Your solutions should focus on creating totally new designs or developing totally new ways of approaching the problem**. Don't be concerned about a particular cost or size of your solution, and feel free to choose any sort of power source that you desire, as those sorts of constraints might be able to be worked out in the future.

Develop solutions for this problem. Focus on developing **practical** solutions. Try to develop solutions that are cost-effective and immediately workable. Be sure to write each solution on a different piece of paper, and use drawings to sketch your ideas. It's important that you do your best and continue working for the full time of the activity.	**Goals** Explicit about type of ideas most valued	Develop solutions for this problem. Focus on developing **radical** solutions. Try to develop solutions without concern for cost or immediate workability. Be sure to write each solution on a different piece of paper, and use drawings to sketch your ideas. It's important that you do your best and continue working for the full time of the activity.

Appendix B. Reflection Survey Perception Items

Dependent measures (perceptions of design ideation outcomes):

1. Creativity (1 = Not creative … 4 = Neutral … 7 = Very creative)
    a. On a scale from 1 to 7, how creative do you feel that your ideas were? Circle one number.
2. Diversity (1 = Not diverse … 4 = Neutral … 7 = Very diverse)
    a. On a scale from 1 to 7, how diverse, or different from each other, do you feel that your ideas were? Circle one number.
3. Elaboration (1 = Not elaborate … 4 = Neutral … 7 = Very elaborate)
    a. On a scale from 1 to 7, how elaborate, detailed, or "fleshed-out," do you feel that your ideas were? Circle one number.

Dependent measures (perceptions of design ideation process):

4. Ease (Difficulty) (1 = Very difficult … 4 = Neutral … 7 = Very easy).
    a. On a scale from 1 to 7, how easy or difficult was it for you to come up with design ideas? Circle one number.

Manipulation checks related to the framing (written description):

5. On a scale from 1 to 7, how much did the **written description of the design task** encourage you to come up with design **ideas that were familiar versus ideas that were new**? Circle one number.
    a. 1 = The written description encouraged very new ideas.
    b. 4 = The written description didn't encourage one sort of idea or another.
    c. 7 = The written description encouraged very familiar ideas.

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