Does Design Thinking Training Really Increase Creativity?
Results from an Experiment with Middle-School Students

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Abstract

Design thinking has become popular at all levels of education. However, it remains mired in controversy. Its proponents claim that it enhances not just confidence but also creativity, but it's opponents question whether it does anything beyond building unfounded confidence. In order to bring rigorous evidence to this debate, we designed a randomized experiment amongst school children served by a major non-governmental organization in rural India. A well-established design thinking intervention for school children comprised the treatment, and the organization's existing science-based intervention for hands-on learning served as the control condition. The findings reveal that the design thinking training did not just increase confidence: it also significantly increased ideational fluency and elaboration in a divergent thinking task, although the originality and flexibility of the generated ideas was on average lower in the treatment group than the control group. The intervention had no effect on perspective taking or risk aversion. We also find that the increase in confidence occurred primarily among female students, whereas the increase in ideational fluency and elaboration occurred for both genders.

INTRODUCTION

Herbert Simon (1996:111) presciently spoke about the science of design and noted its ubiquity: "[e]veryone designs who devises courses of action aimed at changing existing situations into preferred ones." Design thinking relies on the qualitatively distinct mode of "abductive" reasoning (Martin, 2009). Deductive logic is the logic of *what must be,* and reasons from the general to the specific, while inductive logic specifies the logic of *what is operative*, and reasons from the specific to the general. Unlike deduction and induction, which seek to declare a conclusion as true or false, abduction seeks to identify *what is possible*. An influential proponent, David Kelly, the CEO of the design firm IDEO, sees design thinking as a methodology to foster creativity (2013): "What we, as design thinkers, have, is this creative confidence that, when given a difficult problem, we have a methodology that enables us to come up with a solution that nobody has before."

Since its early origins in schools of architecture and art, design thinking (Martin, 2009; Liedtka and Ogilvie, 2014) has been broadly adopted, in both business and education (and business education of course). Stanford's former president, John Hennessy, and David Kelly, the founder of the Stanford Design School and IDEO, have urged that design thinking form part of an undergraduate core in American universities. Design thinking training is also being implemented in a number of high schools ranging from the Nueva School in California to the Riverside School in Ahmedabad, India, with an expectation of lifelong benefits for the students.

However, design thinking has also attracted withering critiques of its principles in general, and its usefulness in education in particular. Consider two extreme examples: Jen (2017) describes design thinking as "business bullshit", and Vinsel (2018) likens design thinking to "syphilis" and opines that design thinking can "rot the brains" of students. These critiques hold that training students on this approach at best generates unfounded confidence not accompanied by real gains in creativity. A more restrained and implicit criticism is offered by Norman and Verganti (2014), who argue that design thinking may likely lead to incremental thinking because of its iterative reliance on feedback, an approach that approximates a local gradient ascent process ("hill climbing"). Despite the hope proffered by the proponents of design thinking, and the skepticism offered by critics of its inclusion in education curricula, there is little systematic causal evidence that examines whether design thinking really enables individuals to be more creative and justly more confident, i.e., whether it genuinely helps develop the ability to come up with new solutions, or just promotes an ill-founded overconfidence that one can solve difficult problems. Further, while the attributes of a particular solution obtained through design thinking are undoubtedly interesting, we believe the impact of design thinking training on general problem solving and behavior is also independently interesting, though as yet understudied.

We were presented with a unique opportunity to bring new evidence to bear on the above issues when Agastya International Foundation, a leading Indian non-governmental organization (NGO) based near the city of Bangalore, invited us in 2016 to participate in their deliberations on the potential value of introducing design thinking training into their educational interventions for school children. Agastya is a highly respected NGO that has traditionally focused on providing middle schoolers an opportunity to learn science through facilitator-guided, hands-on-experiments and peer interaction. Rather than operating schools itself, Agastya strives to complement the existing government schooling system by using weekends and holidays as the time to bring school-going children from rural areas to its campus. Its campus infrastructure is significantly better than the typical state-funded schools in the area, with technical equipment to support experiential (hands-on) science education.

Although Agastya has been relying on science-based educational activities for two decades, its founders are of the view that instilling curiosity, confidence and creativity among students ought to be its ultimate objective. It is in this context that they were interested in investigating how well design thinking training could help deliver on these objectives relative to their current science-based curriculum. For us, the opportunity also seemed an important one to rigorously examine the impact of design thinking training in general – especially as education researchers have identified middle school as a turning point at which such interventions might be particularly influential and have lifelong benefits:

> *"As children move from kindergarten, to middle school, and to high school, instruction shifts from stories to facts, from speculation to specifics, and imagination fades from focus. Design thinking is an approach to learning that focuses on developing children's creative confidence. Students engage in hands-on projects that focus on building empathy, promoting a bias toward action, encouraging ideation, and fostering active problem solving. Using one's imagination is central" (Carroll et al. 2010:38)*

If design thinking failed to have an impact even in this demographic, despite it arguably being the most receptive to its effects (perhaps more so than students in high school or in college), it should cause its proponents to temper their enthusiasm accordingly. On the other hand, if we found evidence that design thinking did produce observable effects that extended beyond confidence to also creativity-related benefits, the results would offer at least a starting point for an evidence-based discussion about the merits of design thinking training more generally. Practically, our study would also provide input to the Agastya leadership team in their thinking about the value of including design thinking in their curriculum, and also possibly inform other such efforts in other NGOs.

Accordingly, taking a "lab in the field" approach towards randomized evaluation, we designed an intervention within the workshop format that Agastya offered on its campus during school holidays. Over four days, middle school students (7^{th}-10^{th} graders) underwent (through random assignment) either a design thinking training program (which we describe in detail below) or the usual hands-on science education curriculum that Agastya delivers. At the end of the fourth day, the workshop closed with measurement of confidence, creativity, perspective taking and risk aversion among participants. Bearing in mind that the training was conducted in the controlled environment of Agastya campus, and that outcomes were assessed immediately after training, the results suggest that the design thinking training had a positive effect not just on measures of confidence (particularly for girls) but also of ideational fluency and elaboration (for both genders) relative to Agastya's traditional science-based curriculum. Further, this was accompanied by a reduction in the originality and flexibility of the ideas generated. We found no evidence for an impact of design thinking training on perspective taking or risk aversion in our experiment.

DESIGN THINKING AND CREATIVITY

Although design thinking is often associated in the popular imagination with the design consulting firm IDEO or the Stanford Design School, its origins can be pre-dated to the pragmatist tradition in American philosophy. In brief, the pragmatic tradition holds that our ideas and theories ought to be evaluated on the basis of their consequences for practice, and this foundational idea informs design thinking as an interventionist discipline different from science and art (Buchanan, 1992).

A singular feature of design thinking, according to writers, is that it deals with wicked problems: a "class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing." (West Churchman, 1967: 141). The principal task in going through the design thinking process is to take the wickedness out of the problem through an iterative process of "seeing" and "doing".

Since Simon (1996) identified seven stages of design thinking, there have been a number of variations. For example, Miller (2015) lists empathizing with users (or, to be more precise, perspective taking), defining a point of view, ideating in a team, prototyping, and testing as the key phases of design thinking. A critical aspect of design thinking is that people learn not just from prototyping but also from seeing how users respond to an early prototype. As a result, design thinking often entails representations which are low resolution and do not require lots of resources. The process begins with a visual or a diagrammatic depiction to prod imagination, which is subsequently and iteratively transformed into more detail via prototyping. In a study of what design teams actually do, Stempfle and Badke-Schaube (2002) found that they first widen the problem space by exploring user worlds and generating problem definitions and ideas, and then narrow the problem space by comparing and selecting among ideas through prototyping and user interaction.

In our study geared to middle school children, we relied on a design thinking training curriculum developed by an organization called Design For Change (DFC) in collaboration with IDEO. The training relies on a design thinking approach adapted for school children, and involves four stages called “feel”, “imagine”, “do” and “share” (meant to be an iterative sequence). The “feel” stage is about observing the user, sensing the user’s challenges, and employing the user’s emotions as sources of data (still a form of perspective taking as it does not assume that the designer experiences the same emotions as the user directly). In turn, when emotions are used as sources of data, it is possible for designers to imagine the problem, to appreciate its wickedness, and to also imagine ways of “taming the wickedness” by generating new ideas. The “do” phase consists of taking the ideas and developing them as prototypes to learn more about the user. Finally, the “share” phase has to do with testing the prototype with users. This design thinking curriculum from DFC is widely accepted and employed with school-age children in India and beyond, with the materials often translated into the local language of students in a particular region.

Elements of Creativity: Fluency, Originality, Flexibility, and Elaboration

In an influential and early paper, Mednick (1962:221) described the creative thinking process as, "the forming of associative elements into new combinations which either meet specified requirements or are in some way useful; the more mutually remote the elements of the new combination, the more creative the process or solution." Guilford (1967) suggested that divergent thinking or producing multiple, related ideas to a set problem is a foundation for creativity, and contrasted it with convergent thinking – coming up with the best answer to a set problem. Jung-Beeman (2005) suggested that divergent thinking entailed lateral connections in a semantic network, and convergent thinking was associated with hierarchical connections among nodes. Building on these, we base our approach to measuring creativity in a divergent thinking task.

Torrance (1981) built on Guilford's account and identified four dimensions relevant to divergent thinking: ideational fluency, originality, flexibility and elaboration. Ideational fluency pertains to the sheer number of interpretable ideas. Originality relates to the statistical rarity of an idea. Flexibility is concerned with the number of categories of ideas. Finally, elaboration is the degree of detail in the description of the ideas. [1] A related distinction identifies two cognitive pathways for creativity: the flexibility pathway, where creativity is obtained by switching across categories, and the persistence pathway, where a large number of ideas are generated by a few categories (Nijstad, et al. 2010).

[1] We thank an anonymous reviewer for this very useful suggestion to study creativity in terms not only of ideational fluency as well as the additional attributes of originality, flexibility and elaboration.

The characteristics identified by Torrance (1981) enable us to discern if design thinking training leads individuals to increase their propensity to: (a) take multiple paths (i.e., ideational fluency); (b) make "long jumps" (i.e., originality); (c) take different directions (i.e., flexibility); and (d) search thoroughly in each neighborhood of a problem landscape (i.e., elaboration). Unlike Norman and Veganti (2014), who see incremental search (hill climbing) as the inevitable result of the iterative feedback seeking involved in design thinking to solve a particular problem, we are thus concerned with the "out-of-sample effects" of design thinking training– how design thinking training affects problem solving in contexts other than the specific one in which the "training" occurred.

Additional Outcomes: Confidence and Perspective Taking

While our primary interest is in examining the impact of designing thinking training on different aspects of creativity as described above, we also examine two other outcomes that seem salient given the literature related to design thinking: confidence and perspective taking.

Confidence is closely associated with people's beliefs – whether well-founded or not – about their capabilities to produce designated levels of performance in exercising influence over events that affect their lives (Bandura, 1994). Recent accounts emphasize confidence in solving problems, and an ability to build on the work of others as an essential concomitant to innovation (Tierney and Farrmer, 2002). Ethnographic studies of design thinking in schools suggest that it leads to enhanced self-confidence (Carroll et al. 2010). Design thinking is likely to improve confidence in particular because a shared understanding of wicked problems can raise awareness that it is not an individual deficiency that makes a problem challenging. The process of prototyping (physical, visual or experiential translations of ideas), sharing the prototypes (to test and learn), and iterating enables individuals to learn from failures and develop confidence. Most of all, design thinking replaces the word "mistake" with the word "prototype" or "attempt", and makes failure a part and parcel of the process of improvement and learning. Accordingly, we also investigate whether design thinking training improves confidence.

Given the critical role played in most conversations on design thinking by the importance of investing in understanding the other person's real needs, and given the emphasis of its proponents on development of perspective taking (Carroll et al, 2010; Miller, 2015), we also examine whether design thinking training improves perspective taking. [2]

STUDYING THE IMPACT OF DESIGN THINKING TRAINING

Empirical Approach

In August 2016, we conducted a pilot involving 255 middle school students in eight rural schools falling within Agastya's operating area (in the state of Andhra Pradesh). The purpose of the pilot was for us to gain familiarity with the local context, Agastya's traditional "Experiential Science Education" (ESE) program, and DFC's designing thinking training curriculum being considered for adoption by Agastya (using a workbook translated into the local language, Telugu). The impressions gathered from our direct observation as well as unstructured interviews suggested that the children engaged well with the design thinking activities, and it also seemed unlikely that there could be adverse effects from the training (besides the opportunity cost of not engaging in other activities at the same time). It also became clear that the logistical challenges of organizing a randomized control trial of the entire DFC training program in the field were prohibitive. Agastya leadership and our research team therefore made the joint decision to proceed with a large-sample experimental study to be implemented in the context of a 4-day workshop held on their campus. [3]

[2] We should note that perspective taking differs from empathy: the former relates to "Can I see the world from your point of view?" and the latter pertains to "Can I feel what you feel?".

[3] More details related to the pilot study are available upon request from the authors.

Before designing our experiment, our first step was to look closely into whether the DFC design thinking training program could even plausibility be related to the outcomes of interest for our study (especially creativity). To do so, we first generated a list of relevant outcomes potentially linked to design thinking that we were able to identify from the literature. We then conducted a (non-random) survey of 20 researchers in organizational behavior departments at our home institutions (business schools), selected based on their academic expertise on being able to comment on the theoretical plausibility of a link between the DFC design thinking training and these outcomes. These experts read through the DFC workbook and provided answered, both in free text format and by expressing their extent of agreement on a Likert scale, in response to our question “What do you think DFC training accomplishes for recipients?” In addition to going through the list of potential outcomes we provided, they were allowed to add additional outcomes. Four outcomes received the strongest support (in the form of a ratings of “strongly agree” or “agree” from at least 50% of these experts):

a. Creativity (being able to think beyond current constraints in coming up with new ideas)
b. Confidence (a belief in one’s own ability to change one’s context for the better)
c. Perspective taking (being able to take the perspective of others)
d. Group work (ability to brainstorm and collaborate in a group)

No other strong contenders for outcomes emerged in the open -ended responses. For our experiment, we decided to focus on the first three of these outcomes – creativity, confidence and perspective taking - because these were most relevant for claims and counter-claims as per our reading of the design thinking literature as well as directly related to issues of interest here (while the fourth - group work - was tangential to our research question).

Our next step in preparing for the experimental study was to identify the "active ingredients" (specific exercises and activities) of DFC's overall workbook that could be considered the core components of their design thinking training. This was necessary because our workshop had to be executed over a few days, while going through the entire workbook back-to-back would require significantly more time. Therefore, given the impracticality of using all the activities comprising the DFC workbook as interventions, we asked a panel of the eight Agastya instructors who had participated in delivering the training during our pilot to identify the core activities within the DFC workbook they expected to have the strongest effects on the intended outcomes. [4] This resulted in the identification of three key design thinking exercises from the workbook for us to subsequently use as a series of specific interventions in our experiment design:

i. "Bag Exercise": an exercise in which students are paired up and design a school bag meeting each other's needs (while cycling through feel, imagine, do and share phases).
ii. "Cartographer": an exercise where the students are asked to carefully talk about their surroundings and asked to identify opportunities for improving life in their community.
iii. "Be a Detective": an exercise where students are asked questions that lead them towards root cause detection and understanding why a solution might work (or not).

Experiment Design

Our study involved testing the impact of the three exercises identified above on the three outcomes also mentioned earlier and were conducted as a multi-day workshop on Agastya's own main campus. Conducting the training over multiple days and using participants drawn from the target

[4] Naturally, we cannot be sure that the impact of covering the entire workbook (whose details are available upon request) would necessarily have the same impact as going through just these specific (even if core) activities as interventions in the actual experiment. However, it seems reasonable to expect that going through the entire workbook would only have strengthened the design thinking training treatment. Therefore, to the extent that even this subset of the activities produces an effect of creativity, the findings can be considered a lower bound.

population brought the experiment closer to field conditions. At the same time, conducting the training as a series of specific activities on campus rather than going through the entire workbook over several weeks in the field guaranteed a degree of experimental control that the pilot had ascertained would be unattainable in the schools. We therefore view our experiment as employing a hybrid "lab in the field" approach that combines some of the benefits of a pure field experiment (such as going through the entire DFC workbook in schools) and a lab experiment (such as using a typical participant pool in a university lab). The experimental protocol was approved by an Institutional Review Board at one of the authors' home universities.

The design thinking experiment was conducted over a period of four days during a period of school holidays. Each day, students came by bus from villages within a 30 kilometer radius of Agastya's campus. The first day (which we refer to as "Day Zero" below) was a preparation day, involving randomized group formation and collection of pre-treatment measures. Random assignment was done by dividing each busload of arriving students into four groups: three treatment groups (groups 1-3) and a control group (group 4) described in detail below. With no definite ideas about effect sizes, we aimed for sample sizes of 50-75 participants in each group.

Treatments and measurements occurred daily over the next three days (which we refer to below as "Day 1", "Day 2" and "Day 3", respectively), with each participant staying throughout in the group they had been assigned through randomization on Day Zero. Each treatment group received the same three DFC design thinking activities identified above, but facilitated by different instructors and in conducted in different sequences (as shown in Table 1). The control group received the standard Agastya ESE program during the three days. All outcome variables used in the analysis below were all measured at the end of the last day (Day 3). [5]

Insert Table 1 about here

Pre-tests in our pilot study had indicated that the students perceived self-evaluation survey questions as self-promotional and not truly descriptive, so we assessed creativity through a task based on Guilford's (1967) divergent thinking task. Two printed forms were used in the test, which in all provided forty circles and asked participants to draw real-world objects using these circles as an integral part. The first sheet provided a few instances of appropriate versus inappropriate use of circles as illustrations, and the second sheet only contains blank circles. The respondents were asked to sketch as many images as they could within a fixed period of time (10 minutes).

We constructed four measures related to creativity, in line with the discussion above and building upon Torrance (1981). The first measure - ideational fluency – was based on a simple count of the number of valid responses (i.e., drawings that adhered to the instructions, though we also check the robustness of our analysis to just a raw count of circles used). A second measure - originality – was calculated as the number of valid categories of objects, inverse weighted by the frequency of these categories in the sample. In this calculation, a category was defined as a broad theme that each response fell into - like "face", "sun" or "flower" (the top three categories in terms of frequency in our sample). The third measure – flexibility - equalled the number of different

[5] As full disclosure, we note that we also attempted to conduct an additional (and shorter) single-day experiment based on a smaller subset of DFC workbook activities and a new sample of students. However, the randomization in that case was unsuccessful (covariate balance was not achieved across groups), making that data unusable for further study.

categories. The final measure - elaboration - was calculated as the ratio of ideational fluency to flexibility (which gives a sense of the extent to which each category was explored in detail).[6]

In addition to measuring creativity along different dimensions as above, we also constructed a few other variables of interest. We measured confidence by following Tierney and Farmer's (2002) procedure of asking people to list the problems that their social unit (village) encountered, and then tick only the problems where they felt that they could make a difference. To measure perspective taking, we asked students to trace the letter "E" on their forehead, with an assumption that writing an "E" facing the direction where it is legible to oneself (rather than the person facing the person) indicates lower perspective taking (Galinsky et al. 2006). Finally, we also used a well-established behavioral approach of measuring risk aversion for exploratory analysis as a possible mediator between the treatment and the outcomes for creativity.

Sample Characteristics

A total of 270 participants began the study. Of these, 195 completed all three days of the study (a 28% attrition rate). Fortunately, there was no systematic difference in attrition rates between groups (F=0.73, df=3, p=0.54). Our analysis is based only on the 195 participants who were present on all three days: group sizes were 52, 55, 43 and 45 participants respectively for treatment groups 1-3 and the control group.

Insert Table 2 about here

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[6] This measure is based on the argument by Torrance (1981) that "adding details that help to bring the idea to life and create a better understanding and appreciation of it. These additional details can often transform an old idea into a new one with greater potential".

The Day Zero demographic survey for the 195 participants revealed that the sample had 119 girls and 76 boys, who were on average 13 years old and had the modal school enrolment in Grade 8. On average, these students had visited Agastya 12 times in the past and had three siblings (two of whom had also been to Agastya). To give a sense of socio-economic status of the children in the sample, we note that 72% of the children had a toilet at home, 18% had a fridge, 84% had a television, and 55% had a two-wheeled motor vehicle. There were no systematic differences in these observables across groups, which is a useful check for validating that the randomization procedure worked as expected (see Table 2). [7]

Results

At end of the workshop (Day 3), we compared outcomes for the pooled treatment groups (groups 1-3, which differed only in order of exercises and instructor) and the control group (group 4 which underwent regular hands-on science training) using OLS regressions. The results are reported in Table 3. We also conducted simple t-tests comparing treatment and control groups. We find that the design thinking training did increase confidence - as measured by the number of suggestions to improve their village that the participants felt they could implement themselves (3.4 vs. 2.5, p=0.02 in a t-test). [8]

Insert Table 3 about here

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[7] While Agastya leaders informed us that the sample of students coming to Agastya is representative of the student population in the region in general, we do not have precise data to back this up. Therefore we cannot conclusively claim generalizability of our results to students beyond those with pre-exposure to Agastya activities.

[8] There was no significant difference between participants in the treatment groups (pooled) and the control group in the absolute number of suggestions to improve their village, but that is not relevant for measuring confidence.

We turn next to the various dimensions of creativity, which comprise the outcomes of primary interest here. The results in Table 3 indicate that the participants in the treatment groups (pooled) and the control group differed not just with respect to confidence but also on ideational fluency. Specifically, design thinking activities resulted in a greater ideational fluency (5.2 vs. 4.1, p=0.04 in a t-test), measured as the number of valid objects drawn in the circle task. [9] Notably, the effects hold in the pooling of treatment groups that vary in identity of instructors and for different order of conducting the three design thinking exercises. In additional econometric tests not reported here, the effects were also found to be robust to carrying out randomization inference tests.[10]

We do not find the design thinking training to have any significant impact on perspective taking.[11] One possible explanation is that Agastya's science program also makes students good at perspective taking, so there is no difference between the treatment and control groups – especially as most students in both groups had come to science activities many times in the past as well. A theoretically more interesting possibility is that design thinking increases confidence in a way that genuinely undermines perspective taking, dampening its independent positive effect on

[9] Recall that "valid" here means that a drawn object adhered to the specific instructions on how to use the circles for drawing images. But the same result holds even if we measure fluency using just the raw count for the number of ideas generated (more circles filled in: 23.6 vs. 19.9, p=0.02 in a t-test)

[10] In randomization inference tests, the idea is to account for the possibility that the difference between treatment and control is simply based on which units are assigned to the treatment group-even if the treatment itself has no effect. The procedure involves reassigning 'treatment' at random hundreds or thousands of times, to compute the probability of differences under the null hypothesis that the treatment has no effect. Athey and Imbens (2016) urge those who conduct field experiments to use randomization inference because uncertainty in estimates arises naturally from the random assignment of the treatments, rather than only from hypothesized sampling from a large population.

[11] We also developed interim measures for Days 1 and 2 that were not part of the analysis for this project, which only relies on final (Day 3 measures). We had piloted those to help develop additional measures of confidence and perspective taking for possible use by Agastya for future purposes. For perspective taking, for instance, we asked "One of your classmates often does not do his homework. Can you list reasons why he may not have done his homework?" For confidence, we asked "A new project has begun in your school to help keep the playground clean; would you join such a project"? and for creativity, " Make a list of all the things you can do to stop littering in your school". These interim measures were administered uniformly to all treatment and control groups, and while these still need refinement and validation, the pattern of results for these Day 1 and Day 2 measures seem broadly similar to what we obtained with the final day 3 measures after the experiment was competed.

perspective taking.[12] We also do not find the design thinking training to have any significant impact on risk aversion, a link we were exploring as a part of a possible mediation between design thinking and creativity in which risk aversion was involved.

To generate further insight into creativity as the outcome, we also coded our data to measure other creativity-related attributes besides ideational fluency. This was based on the observation that respondents often drew multiple figures related to a single category (e.g., different kinds of flowers). We first classified all drawings into five categories found to up the majority of drawings: "face", "sun", "flower", "clock" and "fan", and created a sixth category "miscellaneous" to capture the long tail of the remaining ones. The three resulting measures we constructed were: originality (one point for each distinct category in a student's response, weighted inversely by popularity of the category in the sample), flexibility (a raw count of different categories in a response) and elaboration (the ratio of ideational fluency to flexibility in a response).

The results of the design thinking training on these measures are reported in Table 4. We control for the raw fluency score as well, though the results are not qualitatively affected by this.

Insert Table 4 about here

These results indicate that, while the design thinking training increased ideational fluency and elaboration, it seemed to suppress originality and flexibility. This supports a view that design thinking stimulates the production of many relevant solutions, but they need not be very novel.

[12] Yet another possibility arises from the fact that, although the design thinking workbook was provided in the local language (Telugu), the perspective taking exercise did rely on English to the extent that the participants had to draw the letter "E". As these were middle school students who had all taken English for several years, we felt reasonably confident that they had the requisite competence at least to be able to draw the "E" correctly. Nonetheless, we cannot fully rule out that the non-finding for this exercise arose in part from their limited familiarity with English.

Post-Hoc Analysis

In further post-hoc analysis, we found that the design thinking training magnified confidence mainly for female students (there is no significant difference across genders in the control group) but bolsters creativity across genders. This pattern was quite robust, occurring in 98% of 1,000 bootstrapped samples. Note that there is a case to be made that, even if all that design thinking did was to boost confidence (without increasing creativity), this may still be a welcome outcome at least for traditionally underconfident sub-groups like female students in rural India.

DISCUSSION

Results from our experiment indicate that design thinking training not only increased confidence but also significantly increased ideational fluency and elaboration in a divergent thinking task, although the originality and flexibility of the generated ideas was on average lower than those in the control group. We found no significant effects of the training on perspective taking or risk aversion. We also found that the increase in confidence was primarily among female students, whereas the increase in ideational fluency and elaboration occurred for both genders. Before we discuss the implications of our results for further theorizing and practice of design thinking, we first highlight certain features of our study design that confer both advantages and disadvantages.

Strengths and limitations of the study

The setting of our study was rural India, and the materials were taught in the vernacular and geared to middle schoolers (grades 7-10). The students were not aware of design thinking before the intervention. The advantages of such a setting include the absence of any priors among trainees as well as a population quite open to such an intervention (given their youth and impressionable age). For us, the fact that we were promoting an evidence-based approach to an important policy decision that might improve some aspects of education for children was in itself an important consideration for selecting this context, especially as the decisions taken by this influential NGO could influence the adoption (or not) of design thinking among education curricula more generally. At the same time, we should acknowledge that the context is undoubtedly unusual, especially for a management audience. In fact, although middle school students in rural India are a large and important population, they need not be fully representative even of other student populations. For this reason, we do not consider our results the final word on the matter.

Another specific aspect of our study is the control condition based on experiential science-based instruction the NGO already had in place. Put another way, our control condition was not the regular tedium of classroom activity. Our choice of a control condition that the NGO has already perfected over the years is desirable in terms of being a strong alternative to design thinking training as a stimulus for creativity. For this reason, it is possible that our results about the effects of design thinking training are conservative in the sense that a control group with no intervention or just a placebo might have led to even stronger results for design thinking training.

We should also note the specific delivery channel of the training: it was conducted in the controlled environment of the Agastya campus rather than a delivery channel that might be easier to scale (such as conducting the training in a regular school). Further, the outcomes were assessed immediately after training. The first observation raises doubts about generalizability at scale, and the second about the possibility of transience of the effects detected. Further research is certainly needed to mitigate these concerns, but we believe our research serves as a useful first effort in the direction of rigorous impact evaluation of design thinking training. There would also be value in extending the empirical setting to not just other kinds of educational institutions but also any other context where design thinking is being considered as a potential tool for increasing creativity.

Finally, our measurement approach and specific measures come with their own limitations. We measured the creative outcomes by coding responses on a single test - the divergent creativity task based on drawing images using circles as an integral component (Guildford, 1967). While measuring ideational fluency through this instrument appears non-controversial, measuring originality or uniqueness is still the subject of debate amongst psychometricians studying creativity (see Kaufman, et al. 2008). Nonetheless, our results do indicate the need to assess further whether design thinking training improves the quantity and/or quality of ideational performance. Our measure of confidence (the number of community issues the participants felt they could make a difference on) was also a self-reported measure and is therefore subject to the usual limitations of self-reported measures. Future research ought to map whether such self-expressed confidence translates into persistence – a vital trait for executing ideas. Relatedly, our study measured and found null effects of design thinking training on perspective taking, but further research could explore the effects on empathy.

Lastly, we did not investigate the impact of design thinking training on group working capabilities, which might indeed be significant. Our reasoning for not studying it was that (a) the impact of design thinking on group process seemed a distinct claim from that about impact on creativity; (b) there are other well studied interventions that affect group process; and (c) the sample size requirements for studying group process would be substantially larger than what we knew we would be able to obtain for our study.

Despite the above caveats, we believe that the evidence gives us stronger grounds than anything we have had so far to believe that design thinking training may deliver on at least some of its claims of increased confidence as well as creativity. Perhaps even more importantly, our results offer a platform for further theoretical and practical development, as elaborated below.

Opportunities for further theorizing

While the results of our experiment are interesting, it should also be noted that we do not identify a specific mechanism that underlies the impact of design thinking. Since neither perspective taking nor risk aversion seem to have been affected by the design thinking training in our sample, these can be ruled out as mediators at least in our study. Our speculation is that meta-cognition therefore might be another potential mechanism. Metacognition comprises both knowledge of cognition and regulation of cognition (e.g. Metcalfe and Shinamura, 1994; Schraw and Moshman, 1995, also see Heyes, 2018). In turn, the former comprises explicit knowledge of one's own declarative or procedural memory as well as conditional knowledge: why, when and where to use strategies. Regulation of cognition includes planning, monitoring and evaluation. If the black-box of creativity works such that human beings are capable of creativity without being able to express how this occurred, meta-cognition implies a glass-box perspective: individuals can "step outside" of the process of thinking to watch themselves solve a problem (Jones, 1980).

A number of studies attest to the possible link between metacognition and creativity (see Winne and Hadwin, 2008; Zimmeman and Schunk, 2011). Jausovec (1994) found that proficient college-age problem solvers relied on formal metacognitive strategies, performed better on open-ended (creative) problems than their poorly performing counterparts, and urged for metacognitive training. King (1991) taught fifth-grade students to ask themselves questions designed to prompt the metacognitive processes of planning, monitoring and evaluating as they worked in pairs to solve problems, and reported that they outperformed students in unguided groups and a control group in a novel problem-solving task. Similarly, Swartz (2001) reported that students provided opportunities to practice reflection, planning and monitoring their thinking did better than others. To our reading, many elements of design thinking stimulate metacognitive thought. Yet, the metacognitive foundations of design thinking have been glossed over. We believe this aspect bears careful investigation and may well yield the conclusion that it is not design thinking per se that matters, but interventions that nourish metacognitive thinking. Although this remains a speculation at this point, we feel it could be an interesting direction for further inquiry.

Another useful observation is that our results hint at a trade-off between comprehensive local search (which ideational fluency and elaboration appear to capture) and more distant search (that are proxied by originality and flexibility). In additional analysis, we found that the correlation between ideational fluency and originality was positive in both treatment and control groups. But it was substantially smaller in the treatment group, which is probably why we observe a positive treatment effect on the former but a negative effect on the latter. At least in our setting, design thinking training appears to increase ideational fluency at the expense of originality and flexibility. This mechanism is distinct from the idea of Norman and Verganti (2014), who conjectured that the iterative feedback seeking in design thinking might lead to incremental innovations. In our context, design training on one set of tasks, shows an impact on the nature of creative problem solving in another; put differently, the close dependence on feedback which Norman and Verganti argued would produce incrementalism cannot be the relevant mechanism in our case. Rather, something about design thinking training that stimulates more energetic and comprehensive local search seems to do so at the expense of long jumps on the problem-solving landscape (Levinthal, 1997). When a group undergoes design thinking training together, their subsequently enhanced ability for comprehensive local search (as defined by a large number of generally similar ideas) may produce coordination advantages. The similarity of ideas within the group may make it easier to select and implement one. Further theorizing and research are required to investigate this, but a conjecture we offer at this point is that design thinking may be far more useful for pragmatic problem solving requiring collective action than for making fundamental breakthroughs in a knowledge domain.

Implications for practice

The implications for policy makers and education reformers are, first and foremost, that design thinking bears closer and more rigorous examination, and that it is possible to provide the same using a framework such as one we have developed. Our results provide an existence proof that design thinking can be useful – it did increase ideational fluency, elaboration and confidence (particularly among girls) in our study. The results also suggest that school-age children – even in an emerging market context like rural India - are a viable target group who can benefit from design thinking. As others have noted, this is a crucial stage in the development of future adult citizens, and it is therefore instructive to consider the effects of design thinking training at this stage (Carroll et al, 2010). That said, a number of unanswered questions remain: Does design thinking improve performance in standardized tests? Does it sow the seed of activism into students? Over the long term, do students exposed to design thinking make different career choices compared to others?

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Table 1: Activities by Day across Groups

Group	Sequence of workshop activities (one per day)
Treatment group 1	Bag/Cartographer/Detective
Treatment group 2	Detective/Bag/Cartographer
Treatment group 3	Cartographer/Detective/Bag
Control group	Experiential Science Education (all three days)

Table 2: Means of Demographic Variables across Treatment versus Control Groups [13]

Variable	Treatment groups (pooled)	Control group	P-value of t-test (unequal variance)
Female	0.6	0.64	0.52
Age (years)	13.11	13.06	0.85
Number of times visited Agastya	11.8	13.1	0.45
Number of siblings	3.18	2.28	0.03
Number of siblings who visited Agastya	1.87	1.97	0.79
Toilet with flush at home	0.7	0.8	0.15
Fridge at home	0.18	0.22	0.51
TV at home	0.85	0.82	0.65
Two-wheeler motor vehicle at home	0.54	0.62	0.33

[13] ANOVA tests accounting for sub-groups within treatment groups give qualitatively identical results.

Table 3: Treatment Effect of Design Thinking Training with Covariates as Controls

	Confidence	Ideational fluency (valid circles)	Perspective taking
Treatment Group	**0.90 (0.00)**	**1.22 (0.00)**	-0.10 (0.23)
Age	**0.15 (0.09)**	**0.31 (0.03)**	**-0.05 (0.05)**
Gender	0.38 (0.21)	0.70 (0.11)	0.00 (0.957)
Familiarity with Agastya	0.00 (0.55)	**0.06 (0.05)**	0.00 (0.75)
R-squared	0.05	0.12	0.04
F	**3.53 (0.01)**	**5.71 (0.00)**	1.35 (0.25)

Note: OLS regressions; exact p values from robust standard errors in parentheses, bold indicates significant at p<0.10

Table 4: Investigation of Additional Aspects of Creativity

	Originality	Flexibility	Elaboration (Ideational fluency/Flexibility)
Treatment Group	**-0.22 (0.04)**	**-0.28 (0.06)**	**0.43 (0.00)**
Divergent Creativity (Raw)	0.00 (0.94)	0.01 (0.24)	**0.01 (0.07)**
Age	**0.09 (0.02)**	**0.17 (0.01)**	0.01 (0.85)
Gender	0.12 (0.23)	**0.44 (0.01)**	-0.03 (0.75)
Familiarity with Agastya	**0.01 (0.05)**	**0.02 (0.05)**	0.01 (0.35)
R-squared	0.12	0.14	0.10
F	**5.34 (0.00)**	**8.61 (0.00)**	**10.59 (0.00)**

Note: OLS regressions; exact p values from robust standard errors in parentheses, bold indicates significant at p<0.10