Expanded Payoff Matrices and Drawing: Design Methods for Creating Value through Positive Sum Design

Ian Gonsher[1], Racheal Arewa[2], Zoey Zhang (Zhiyu)[3], Charlene Chen[4]

[1, 2, 3, 4]Brown University, United States

Abstract

Creativity can be characterized as a process that produces novel and useful outcomes. Positive Sum Design seeks to harness this kind of creativity in order to generate the greatest aggregate value for all stakeholders, eschewing scarcity in favor of abundance, and overcoming zero sum bias. Collaborating with undergraduate design engineering students, these design principles were workshopped into a set of design methods. These design methods enhanced the creative process by supporting divergent thinking - the ability to generate many different outcomes. Participants were able to generate an impressive range of possibilities through iterative sketching, as they mapped those possibilities in relation to each other through the use of an expanded payoff matrix (based on the traditional payoff matrices taken from Game Theory). Participants were given a scenario involving a limited resource (an umbrella). When first encountered, the conditions seemed unable to support the needs of all stakeholders. However, through the implementation of these Positive Sum Design methods, participants were able to create positive sum value and generate diverse solutions to the given problem.

Keywords: *Positive Sum Design, Design Process, Divergent Thinking, Design Education, Game Theory*

1. Introduction

It is raining hard outside. You and a co-worker are about to leave the office to go home for the evening, but you both realize you did not bring an umbrella. As luck would have it, another coworker has left an extra umbrella that you can borrow. You have several immediate options. You can take the umbrella, which will keep you dry, but your co-worker will get wet. They can take the umbrella, which will keep them dry, but you will get wet. You can share the umbrella, but it is not big enough to keep both of you completely dry, although you will both get less wet than if you had nothing at all. Or, in the interest of fairness, you both agree that no one should have an umbrella. What would you do? We gave this scenario to undergraduates in order to initiate a discussion about the different design interventions that might be possible. The question has an implicit utilitarian premise. How might you produce the best possible outcome for the most people? In order to answer that question, one must consider who the players are, what their incentives are, and what the best strategies they might take to achieve what they all see as their best interest. The results could produce a zero-sum game, as would be the case if one or the other worker chose the umbrella for themselves at the expense of the other. But the question we are ultimately posing to the students is a matter of how the given situation might be reframed into a scenario where the needs of everyone can be met.

This logic is the foundation of a design approach called Positive Sum Design. Positive Sum Design asserts that good design seeks to create value between agents (positive sum), rather than simply re-allocate value (zero sum). The design methods presented herein reflect this ethical stance, which is to say, that design should be put in the service of producing positive outcomes for all stakeholders. The ethical question might be further simplified: Is it ethically permissible to pursue a zero-sum strategy when positive sum options exist? Or to put it even more prosaically: why allow losers when a bit more creativity can help everyone win according to differing incentives and context? These exercises attempt to frame that metaethical question, by demonstrating that options for win/wins do exist, even when not immediately recognized, if a proper framing is cultivated and applied. These design methods attempt to provide some of that framing or reframing, as the case may be. These design methods enhance the creative process, critiquing bias for competition and scarcity towards a preference for the design of affordances that foster cooperation and abundance, for the positive gains of everyone involved.

Two people under one umbrella may seem to be competing for limited space—but staying dry doesn't require standing under the same cover. What appears to be a zero-sum scenario can be reframed to uncover

overlooked solutions that benefit everyone. This insight reflects the ethical shift at the heart of Positive Sum Design: by rethinking constraints, questioning assumptions, and enabling collaboration, designers can uncover hidden value and create outcomes that serve all stakeholders.

1.1 Design Methods: The Sketch and the Pay-Off Matrix

Conventional design engineering often assumes scarce resources and emphasizes trade-offs. Positive-Sum Design (PSD) challenges this by broadening constraints and promoting cooperation to generate outcomes where all stakeholders benefit. This reframes design from local optimization ("my user wins") to maximizing system-wide utility ("the system wins"). In education, PSD fosters a shift from zero-sum thinking to collaborative, multi-party problem-solving.

This paper introduces design methods that help students create positive-sum solutions—those that enhance collective value. Developed through critical design workshops, these methods integrate sketching and payoff matrices to support divergent thinking and challenge assumptions of scarcity. Together, these tools help reframe context, incentives, and resource availability, making PSD more accessible and actionable in both academic and professional settings.

Beyond sketching with paper and pen, Positive Sum Design design methods stimulate divergent thinking by employing modes of representations taken directly from Game Theory. Workshop participants were encouraged to map out the possibilities identified through their initial drawings as a payoff matrix. A payoff matrix is a table that maps the outcomes for each player in a strategic game, given the combinations of strategies and incentives chosen by all players [16]. The payoff matrix enables a bird's-eye view of stakeholder interactions across contexts and incentives, complementing drawing's focus on specific solutions. Together, they reveal possibilities that may otherwise go unnoticed.

A payoff matrix maps out the possible incentives and outcomes of a strategic interaction between multiple players. It is a tool for visualizing how scenarios between different agents might interact and has been a foundational in economics and political science since its formalization by von Neumann and Morgenstern in Theory of Games and Economic Behavior [21]. In traditional Game Theory, the payoff matrix enables analysis of cooperation, competition, and strategic equilibrium, e.g. the Nash equilibrium [16]. These matrices clarify how individual strategies align or conflict with the outcomes of others, helping reveal zero-sum, negative-sum, or positive-sum scenarios. While game theory traditionally focuses on rational actors in simplified conditions, its models are increasingly leveraged in fields beyond economics, including sociology, evolutionary biology, and design [4].

1.2 Expanding Value through Divergent Thinking

Creativity can be characterized as a process that produces outcomes that are both novel and useful [20]. Positive Sum Design (PSD) fosters creativity, in part, by integrating traditional design methods with insights from Game Theory in order to reframe problems and maximize collective value. Using tools such as sketches and payoff matrices, PSD fosters creativity through divergent thinking—generating multiple varied possibilities and applying those possibilities to useful applications. In his American Psychological Association (APA) presidential address, Creativity, Joy Paul Guilford defined divergence as the moment when "the thinker must do much searching around, often in several directions at once, for ideas that are both numerous and varied" [10]. Subsequent work corroborates Guilford's claim that idea generation is an exercise of cognitive aptitude. Meta-analyses show that people who earn higher scores on divergent-thinking tests are, on average, more likely to achieve creative success later in life [13] and to have their work rated as more creative by expert judges [18]. While correlations between divergent thinking and creative success are moderate, they remain significant. Convergent thinking, by contrast, focuses on narrowing options to find the most effective solution. Both models are essential to creativity and can be strengthened through visual methods that make abstract thinking tangible.

Divergent and convergent thinking entered scholarly discourse through J.P. Guilford's 1950 APA address, where he argued that creativity consists of multiple cognitive processes. He later formalized these ideas in his Structure-of-Intellect model, identifying fluency, flexibility, originality, and elaboration as core divergent thinking skills. In the 1960s, E.P. Torrance translated Guilford's framework into practical tools by developing the Torrance Tests of Creative Thinking (TTCT). These tests, comprising verbal and figural tasks, evaluate creativity through Guilford's four dimensions and have demonstrated predictive validity in longitudinal

studies [20]. One notable figural task involves transforming repeated circles into distinct objects, directly assessing flexibility and originality. This concept evolved into the 30 Circles Challenge, popularized by Stanford professor Bob McKim and later adopted by IDEO, serving as a rapid exercise to enhance creative fluency under time constraints. Whereas TTCT circles are scored analytically, the 30-Circles exercise is typically used formatively to help teams experience the difference between idea quantity and quality. Ultimately, the exercise exemplifies Guilford's divergence and convergence axes of creativity.

Complementary tools capture other facets of creative cognition. Sarnoff Mednick's Remote Associates Test (RAT) taps convergent insight by asking solvers to discover one word linking three remote associates, emphasizing tight semantic closure rather than generative breadth [20]. Alternatively, Teresa Amabile's Consensual Assessment Technique (CAT) sidesteps psychometrics entirely. Panels of field experts rate real products for creativity, bringing domain specific standards into the evaluation process [20]. Collectively, these measures provide a multifaceted toolkit for studying how people navigate from many possibilities to a single, high utility solution.

Sketching stimulates and concretizes divergent thinking. Studies underscore that drawing actively expands the outcome space of possible solutions by leveraging the very cognitive traits that support divergent thinking [19] [13]. Sketching plays a vital role in fostering divergent thinking and creativity. Boldt and Strub [2] found a strong link between conceptual flexibility and drawing creativity, highlighting sketching as a pathway to novel ideas. In design engineering, sketching supports "value exploration" by revealing hidden needs and enabling shared understanding [11] [5]. Visual tools invite critique, spark analogies, and build trust—critical for Positive Sum Design. Even quick exercises like the Circles Test show how manipulating constraints visually encourages flexible, collaborative thinking.

1.3 Game Theory and Human-Centered Design

Designers are well accustomed to employing user scenarios to better understand what they are designing and who they are designing for. Human-centered Design (HCD) emphasizes empathy and iterative development to meet user needs [3]. Tools such as user journey maps and user personas are just some of the tools used in HCD to better understand who an individual user is and how they might navigate the circumstances and constraints of a proposed situation. As noted by Don Norman, one of the leading proponents of HCD, the aim of HCD is to create technology and products that are "usable, useful, and desirable" [15].

Traditional payoff matrices are useful because of the constraints they offer. They focus the scenario around a given number of possible players, strategies, and outcomes [1]. However, constraints also limit the kinds of behaviors and choices that can occur, and ultimately the utility or value that can be enjoyed by the players, albeit in varying proportion to one another. Constraints are useful in helping to define the design problem, which in turn can be iterated upon and further developed. Within the design process, it is often necessary or desirable to find a balance between thinking within the given constraints, and also thinking beyond them. Failure of imagination can result if the scope of the problem is too limited.

While Human-Centered Design focuses on individual users, Positive Sum Design shifts attention to multiple agents and how their interactions affect collective value. To support this broader perspective, we introduced an expanded payoff matrix—a tool that goes beyond the traditional game-theoretic model, which tends to converge on a single optimal outcome. Instead, our matrix encourages divergent thinking, helping designers explore a wider range of perspectives and outcomes. By mapping user behaviors, incentives, and interactions onto this matrix, designers can "reframe the game" to uncover new possibilities. This foundation supports visual ideation: sketching tangible interventions within richer, more nuanced scenarios. When combined with prototyping and refinement, this approach enables interventions that increase value for all stakeholders.

2. Workshop: Applied Positive Sum Design

To develop and evaluate Positive Sum Design (PSD) methods in practice, we conducted two complementary workshops at Brown University: a two-hour studio session involving 13 undergraduates and an asynchronous online workshop which welcomed participants from a wider range of academic backgrounds. Both formats led participants through a scaffolded sequence that moved them from zero-sum reasoning to win-win framing, demonstrating how structured play, visual ideation, and game-theoretic framing can foster

creative, cooperative problem-solving in design education. The workshop followed a structured progression that blended brief concept overviews with interactive practice. After a short comparison of positive-sum and zero-sum frameworks, participants undertook a series of hands-on exercises designed to encourage divergent thinking and collaborative problem-solving.

First, a Haystack Exercise ("How would you find a needle in a haystack?") was used to measure divergent thinking, with responses scored for fluency, flexibility, and originality. Next, students tackled the primary Umbrella Scenario: they sketched solutions and mapped strategies on payoff matrices to design mutually beneficial outcomes. Creative outputs were evaluated using the Consensual Assessment Technique (CAT) and Torrance Tests of Creative Thinking (TTCT). The session concluded with a group discussion and a reflection survey to gauge shifts in perception and strategy.

Throughout the session, the instructors highlighted the contrast between zero-sum assumptions and positive-sum possibilities, stressing how reframing constraints and employing divergent thinking can lead to integrative solutions. Students participated actively and collaboratively, frequently expressing surprise at the innovative win-win ideas that emerged and noting how these activities made abstract theory tangible, thereby deepening their understanding of PSD. In the first iteration of the expanded payoff matrix exercise, students ranked four introductory scenarios— keep the umbrella, give it away, share it, or decline it—and then translate these rankings into a traditional payoff matrix [Figure 1].

Explaining their choices allowed them to link quantitative rankings with qualitative reasoning. The cohort subsequently discussed varying incentives and explored possible Nash equilibria, each player's optimal strategy given the other's, highlighting how different frames influence cooperative outcomes.

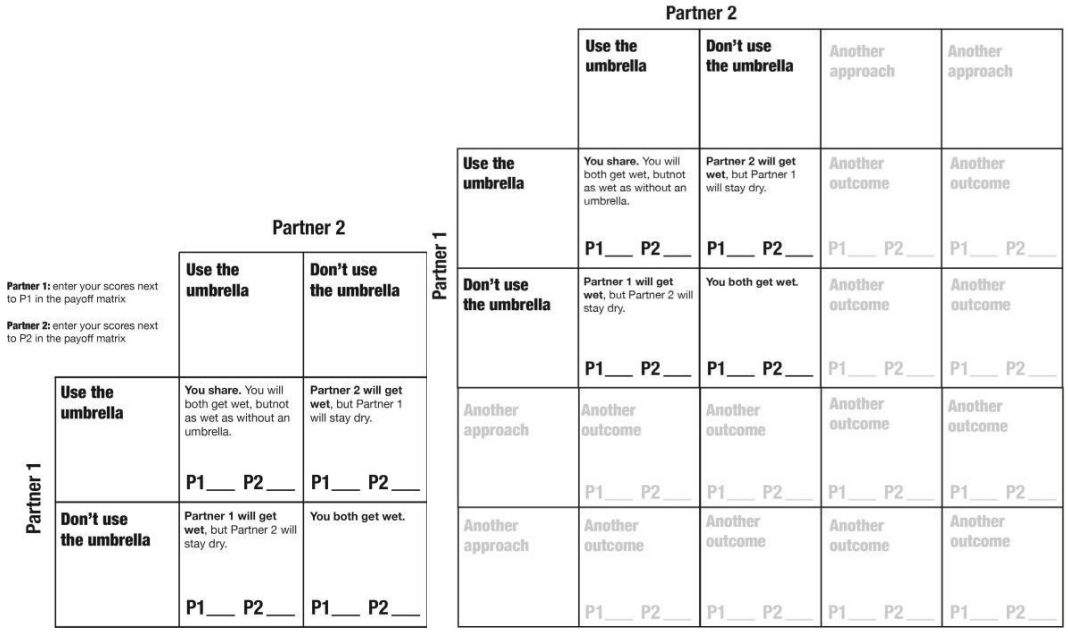

Fig. 1. Payoff Matrix vs Expanded Payoff Matrix

The second iteration introduced an expanded payoff matrix. Like the traditional version, this matrix uses rows and columns to assign values to different interactions between agents. However, whereas the traditional matrix focuses on convergent thinking, identifying a single optimal outcome, the expanded matrix encourages divergent thinking by reframing constraints and exploring possibilities beyond the initial conditions. Students first brainstormed additional options, then mapped these options onto the expanded matrix to visualize the broader set of potential outcomes. After a round of discussion and collaborative refinement by the entire cohort, students were asked to concretize and visualize their newly generated options, adding specificity and detail to each proposed design intervention. [Figure 2]

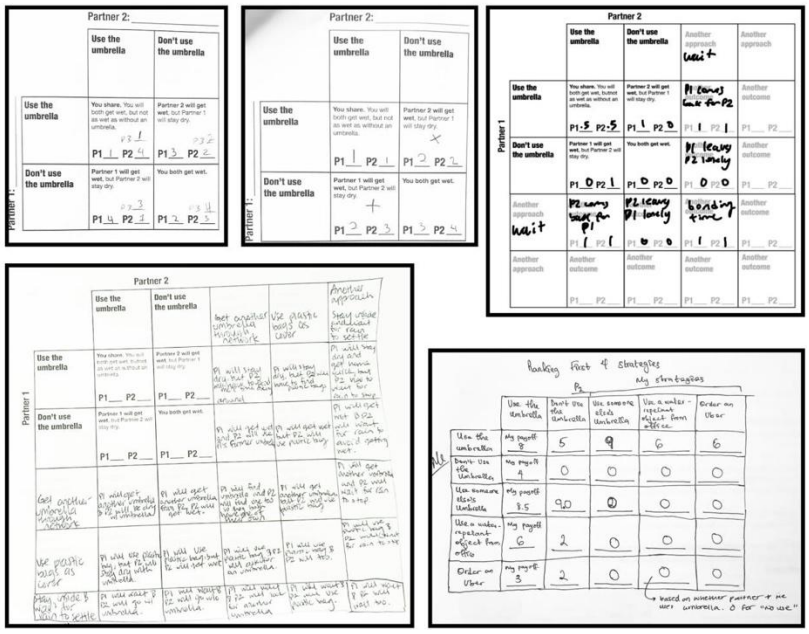

Fig. 2. Student Payoff Matrix

Drawing is a robust cognitive tool for exploring creativity and value generation. Recent studies have shown that drawing tasks activate divergent thinking pathways and allow creators to explore abstract concepts spatially and relationally [2]. In PSD contexts, drawing allows participants to test how a design might perform for multiple users, evolve with needs, and curate an intended experience. These sketches are not merely illustrations, but rather strategic moves within a game of collective gain.

To evaluate these drawn solutions, we can apply tools developed in developmental research [20]. The Consensual Assessment Technique (CAT) offers a method where experts evaluate individuals' creative performance on open-ended tasks. Domain expertise and contextual problem-solving ground the CAT method, distinguishing it from other scales of creativity. In the workshop's scenario, participants are tasked with proposing creative alternatives to the limited choices presented by the traditional zero-sum setup: either one person benefits or both incur partial losses.

To apply CAT rigorously, recruit a panel of independent judges familiar with design, creativity research, or human-centered problem-solving. Judges do not compare drawings to a fixed rubric, but instead rely on their respective understanding of creativity and social value. The strength of CAT is in capturing subjective yet consensus-driven assessments, allowing for nuance that rigid scoring schemes might miss. By applying CAT to these sketches, researchers and facilitators can simultaneously identify which ideas are "creative" and which foster a positive sum outcome. This, in turn, allows for an empirical yet holistic way to populate a new kind of payoff matrix– one in which outcomes are optimal, collectively meaningful, and adaptable.

To complement CAT, the Torrence Tests of Creative Thinking (TTCT) offer a structured framework for assessing participants' creative thinking during the workshop. Originally developed by E. Paul Torrence, TTCT evaluates four dimensions of creativity: fluency, originality, flexibility, and elaboration. In the context of our design workshop, TTCT provides a structured way to assess the creative output of participants as they engage in divergent thinking activities, such as sketching prototype solutions. This standardized test is therefore highly relevant in the workshop context as an objective means to evaluate the creativity of the design solutions generated, offering a benchmark for creative performance beyond subjective judgment.

Within the TTCT dimensions, fluency is measured by the number of distinct ideas a participant produces, indicating their ability to think beyond conventional solutions. Flexibility refers to the diversity of conceptual approaches reflected in their sketches, particularly in how they address PSD principles. Originality is assessed by the uniqueness of a solution within the pool of responses. Ideas that appear infrequently or diverge significantly from the norm are marked as more original. Elaboration evaluates the depth and clarity

of the participant's thinking, rated on a scale from minimal to comprehensive, based on the extent of explanation and contextualization provided.

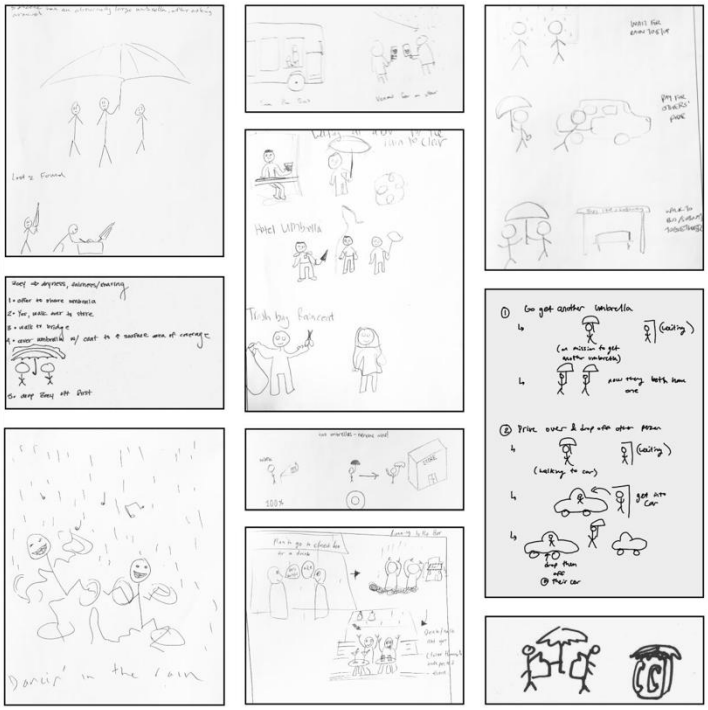

Fig. 3. Selected student sketches for the umbrella scenario

Together, these dimensions offer insight not just into how creative a response is, but how effectively it addresses the real-world challenge at hand. Divergent thinking, in this context, is not measured in isolation but in terms of its capacity to produce value, relevance, and mutual benefit.

3. Discussion

Despite the modest size of the workshops, participants proposed a thoughtful range of creative strategies, grouped thematically into several categories. Some participants attempted to redesign the object itself, proposing technical design solutions such as double umbrellas or a portable drone system, for example. Others attempted to reframe the given constraints in order to discover new ways of addressing the need, such as shifting the functional fixedness of adjacent objects in order to adapt them to serve that desired utility. Participants discovered much ready material to work with by opening themselves up to other possibilities, such as protecting themselves from the rain with objects ranging from trashcans and trash bags to jackets and newspapers. And still others attempted to reframe the utility of the object by expanding the incentives beyond what was initially apparent. These participants not only asked, "What do I want and how do I get it?" but perhaps a more foundational question, "Why do I want what I want?" Some of these participants realized that staying dry might not be the best possible outcome at all. They discovered that it might be more desirable to enjoy the rain, for example (e.g. dancing in the rain) or use the circumstances as a ready reason to take a sick leave the following day.

The workshops occasioned a wide variety of approaches to the given problem, with most falling into these three categories. Some tried to improve the design of the umbrella itself. Others expanded the resources available to them by applying the given constraints to the broader context in which they found themselves. While still others fundamentally questioned the premise of the given goal in order to explore other ways to understand their needs. All of these strategies lead to the discovery of otherwise unrecognized value.

Nearly everyone's initial instinct was to share and avoid the "all wet" outcome, but altruism vs. self-interest varied by group. Weather severity, health, distance, and the relationship history of the participants could lead to a change in the ranking order. Buying, borrowing, waiting, splitting a cab, or improvising rain gear

often transformed a competitive zero-sum dilemma into a cooperative win/win. Viewing the umbrella as a resource that can shift from a “rival” or “excludable” good to “public “good (by sharing or adding another umbrella) led stakeholders to constructive tensions, which ultimately encouraged higher-value mutual solutions. Communication between stakeholders, including the use of visual representations such as rough sketches, were key to this shift. Drawing not only helped to generate new possibilities that were novel and useful to all stakeholders, but aided cooperation and coordination between those stakeholders as well.

Our analysis also compared traditional payoff matrices with expanded payoff matrices. The expanded payoff matrix helped stakeholders map out and visualize the available options, and helped stakeholders identify where reasonable trade-offs could be made. This allowed all stakeholders to shift from a zero-sum scenario, where wins come at the expense of losses, to positive sum games, by growing resources, reframing the constraints, and redefining the need.

In the initial zero-sum scenario, participants generally defaulted to solutions that maximized their own dryness at the expense of the other, mirroring the expected Nash equilibria. For example, Group A had two participants share the umbrella while the third member resorted to using a trash bag for coverage. One could argue that these outcomes extrapolate a focus on self-interest and resource scarcity. As a result, there are limited payoff options and minimal mutual benefit.

When prompted to use the expanded payoff matrix, the diversity and utility of ideas noticeably increased. Group B proposed supplementary factors to the scenario to bypass the initial constraints. Their ideation included collaborative solutions, such as using the umbrella by one member of the team to seek resources for the rest of the group, e.g. trekking to dry environments such as a nearby hotel to call an Uber or otherwise using the single umbrella to search for additional resources that allowed for coverage of all stakeholders.

Group C devised a systemic solution that went beyond the immediate scenario, designing a workforce umbrella-sharing program. Alternatively, Group F and E focused on technical improvements to the umbrella itself, sketching a dual umbrella prototype where the product adjusts based on height and circumference. The expanded payoff matrices reflected higher aggregate utility in all these scenarios. All parties stayed dry, or at least less wet, while also adapting resources and reallocating risk. Across the six teams, participants produced an average of 8–10 distinct ideas beyond the standard two options. Not all were sketched; however, in almost all cases, the act of drawing clarified assumptions, exposed contrasting features, and invoked more novel combinations, consistent with research showing visual ideation boosts flexibility and elaboration.

In our initial pilot evaluation, we focused primarily on the TTCT subscales of flexibility and originality, since these dimensions most directly mapped the PSD principles of mutability of constraints and multivalence of utility. However, fluency (the sheer number of ideas generated) and elaboration (the depth and detail of those ideas) are equally critical facets of creative potential. In future work, we hope to incorporate timed fluency tasks where participants produce as many illustrations as possible to capture how volume drives discovery. Likewise, the hope is to integrate elaboration prompts by asking participants to annotate or color-code their top ideas, documenting the “how” and “why” behind each solution. These richer artifacts can then be scored both for idea count and for the granularity of their execution, yielding a more holistic profile of divergent thinking. Integrating sketches and payoff matrices enabled participants to quantify and communicate differential gains. The use of sketches and payoff matrixes within the design process helped stakeholders generate and capture new value by developing unconsidered possibilities and mapping the outcomes of those possibilities against each other.

4. Conclusion

Drawing and mapping complement each other, the former allowing for the generation of varied, individual possibilities, with the latter allowing for a systemic view of how those possibilities relate to each other as a whole. Although the sample for these pilot workshops were small, the results offer promising evidence for the efficacy of these design methods in producing greater aggregate value for all stakeholders. The expanded payoff matrix, in conjunction with visual design methods such as sketching, can convert perceived scarcity into positive-sum outcomes.

The fundamental ethical question that PSD poses is to ask if it is permissible to play a zero-sum game when possibilities for playing positive sum game either already exist or can be developed by means of a creative engagement with the problem? Is there an ethical obligation to challenge one’s own bias towards zero sum framing? Is there an ethical obligation to overcome failures of imagination? Is there an ethical obligation to

cultivate creativity? Is one compelled to think creatively in order to expand the available resources for all stakeholders, and facilitate cooperation and communication over direct competition?
PSD methods attempt to address this need. These design methods give designers and stakeholders a means by which they might visualize the complexities that arise from the differing incentives and changing constraints between the interplay of multiple users within a given context. PSD offers designers tools for enhancing divergent thinking and expanding the available resources against assumptions of scarcity. These insights can then be further ideated and visualized and prototyped, as the design process culminates in the best possible solutions for all stakeholders.

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