When Design Novices and LEGO® Meet: Stimulating Creative Thinking for Interface Design

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ABSTRACT

Design thinking is an iterative, human-centered approach to innovation. Its success rests on collaboration within a multidisciplinary project team going through cycles of divergent and convergent ideations. In these teams, non-designers risk diminishing the divergent reach because they are generally reluctant to sketch, thus missing out on the ambiguous, imprecise early conceptual divergent phases. We hypothesized that LEGO® could advantageously be a substitute to sketching. In this comparative study, 44 non-designers randomly paired in 22 dyads did two conceptual ideations of healthcare landing pages, one using pen/paper (spontaneously writing words on sticky notes) and the other using LEGO, assessed through Torrance and Guilford frameworks for divergent thinking. Results show that LEGO interfaces gathered significantly higher divergent thinking scores because their concepts were significantly more elaborated. Furthermore, when using LEGO, teams who generated more elements were likely to also generate more ideas, more categories of ideas and more original ideas.

Author Keywords

Creativity Support, Design Methods, Tangibles, User Experience Design.

CSS Concepts

• Human-centered computing~Laboratory experiments • Human-centered computing~User interface design • Human-centered computing~Interface design prototyping • Human-centered computing~Participatory design • Human-centered computing~Empirical studies in interaction design

INTRODUCTION

“Design thinking is obsessed with only one tool: Post-It Notes!” says designer Natasha Jen, partner at Pentagram in NYC [39]. Jen’s dramatic effect aside, we have to concede that sticky notes are used a lot in design thinking. A tool is

a cognitive artefact responding to specific needs and abilities to fulfil a specific function; it would be surprising that any one tool could answer the needs and abilities of every design thinking participant the world over. Design thinking (DT) has been widely popularized across multiple industries and practices [12] none the least in human-computer interaction (HCI). David Kelley [81], who coined the term and helped establish the practice, defines DT as a human-centered approach to innovation. To reap innovation from DT, a number of criteria need to be met, two main ones being to 1) involve stakeholders and to 2) fully engage in the iterative cycle of divergent and convergent thinking [5, 12, 58].

DT gathers the stakeholders of a given project, some of which will be from the design team while most will be non-designers, such as users, consumers, IT, marketing, and business leaders [12, 42, 45, 57, 74]. This “us-with-them”, designers with non-designer stakeholders, is central to DT [13]; it gives stakeholders the opportunity to engrave their reality and perspective into the solution [26]. During DT sessions, they will engage with divergent and convergent phases [15, 32]. Convergent thinking seeks a single best solution whereas divergent thinking produces a multitude of alternative solutions [15]. However, design novices who are not trained or accustomed to the divergent thinking process will tend to fall back to their knowledge domain, which often brings a strong inclination toward convergent thinking [20, 22]. Such a situation may prove to be a challenge to strike right balance between divergent and convergent phases.

DT workshops are typically fast paced, onsite, hands-on and non-digital cycles of co-design sessions [12, 89]. Various tools and resources might be used, for instance, creativity-inducing games and scenarios, or visual and collaborative tools [27, 56]. Design research literature has long recognized the key role played by sketching as a prime mode of producing representations of newly formed ideas during early (or conceptual) ideation [25, 31, 33, 44, 62, 63]. Early or conceptual ideation is the moment where co-designers link not-yet-fully formed mental images to visual representations through continuous interactions [82]. It is the moment where new ideas emerge and where team members share and expand on each other’s ideas.

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However, relying on sketching during conceptual ideation might not be the best strategy considering the important presence of novice designers in co-design sessions [57, 74] as most design novices are reluctant to draw [9]. Instead, most non-designer dominated teams will typically use sketching material, pens and paper (and sticky notes!) to write down ideas they want to share. By shying away from sketching and its cognitive advantages of ambiguity, flexibility and impreciseness, the process of coming up with new ideas risks being prematurely accelerated [9].

So, although non-designers are very much desired and are central in DT endeavours, if the divergent phase is compromised because novices do not fully understand or trust the divergent process and shy away from tools that support a slow maturing of new ideas, then DT may fall short of delivering truly innovative solutions.

Thus, we asked ourselves what could substitute to sketching and seamlessly steer design novices towards divergent thinking. This substitute should be easy to use, intuitive and have a short learning curve. After considering a number of different tools (clay, card decks, Playmobil®), we focused on tangibles even though there is limited knowledge on how and why tangible design tools affect creativity [11]. Because of their “ready-made” nature, assembling tangibles do not require any particular creative skills, compared to sketching. We decided to put the LEGO® system to the test as it is said to “*support the representation of ideas and the organization of thinking* [... as well as permitting to] *build metaphorical models*” [28, p. 4-5].

Consequently, our research question is: *How does the use of LEGO® compares to that of pen and paper the during collaborative conceptual ideation phase?* The goal of this study is to see if a tangible figurative tool could replace sketching for non-sketchers and if it could lead them toward a stronger divergent thinking phase than pen and paper does (pen/paper being the current default). We hypothesized that pairs of non-designers *using LEGO®* for the early ideation phase of an HCI project would deliver *interface proposals showing greater divergent thinking* than when using pen/paper (H1).

Considering that using LEGO to conceive of a 2D interface might be challenging for most people, we decided to test if using LEGO in an HCI project requires a special preparation. Half the teams did a warm-up activity developing LEGO-focused skills, while the other half did not (the control group). Our second hypothesis is that the teams who experienced the *LEGO-focused warm-up* would deliver LEGO interfaces *showing greater divergent thinking* than those from the control group (H2).

We have conducted a between subjects mixed factorial design lab experiment to these hypotheses. The two factors were: the medium (pen/paper vs. LEGO) and the preparation for the two ideations (LEGO-focused vs. non-LEGO-focused warm-up). The experiment was conducted

with 44 participants (all design novices), randomly paired in 22 dyads, who carried out early ideations of two web interfaces, one using pen and paper (to draw or write with as they chose; see Figure 1), the other using LEGO pieces (see Figure 2). The present study builds on the results of, and replicates the settings of Lesage et al.’s study [52] while overcoming its main limitation, i.e., it was conducted with individual participants rather than in collaboration. The use of dyads makes for stronger ecological validity since DT is always done in a collaborative setting. The 44 resulting interface proposals (i.e., two per dyad) were assessed according to Guilford [85] and Torrance [79, 80] frameworks for divergent thinking, on their levels of elaboration, fluency, flexibility and originality [64, 80].

Our results show that the tangible tool does stimulate divergent thinking better than tagging words on sticky notes (H1, supported), but doing a LEGO-focused warm-up appears to have no significant impact on the divergent quality of the output (H2, not supported). Moreover, when using LEGO, teams who generated more elements were likely to also generate more ideas, more categories of ideas and ideas that were more original.

The main contribution of this paper is twofold: first and more interestingly, our study suggests an explanation as to *why* a tangible tool, such as the LEGO system, yielded more divergent ideation results. Second, our study also sheds new light on the use of the Torrance Test for Creative Thinking framework to assess the creativity of design representations (in contrast to its original use of predicting individuals’ creativity potential). We also propose greater precision in the operationalization of the concept of originality as it applies to design representations.

RELATED WORK

Design Thinking, Creativity and Divergent Thinking

DT’s creativity stems from the interactions between co-designers [84]. When it comes to developing new interfaces, the similarities between HCI design process and the DT process may give the impression that they are similar co-design problem-solving processes. However, the HCI design processes usually involve incremental innovation (e.g., new versions of existing software) [16], whereas DT is focused on radical innovation through divergent and convergent thinking [64] borrowing from creative design methods [81].

Convergent and divergent thinking operate in diametrically opposite fashion [22]. In the former, participants attempt to converge on and reveal “facts” whereas with the latter, participants intend to bring forth “*alternative known answers and to generate unknown possible ones*” [22, p. 105]. Convergence operates in the *knowledge domain*, i.e., identifies a proposition or group of propositions that could realistically take form within the known reality and constraints of particular domain. Divergence, on the other

hand, operates in the *concept domain*, i.e., in the conceptual space of potential solutions responding to a need [22, 36]. Thereby, DT can be seen as an iterative cycle moving from concept domain to knowledge domain and back again. But if the divergent thinking phase of the cycle is not understood or trusted, the call from the knowledge domain may keep the DT interactions in convergence mode.

Yet, of the two DT phases, divergent thinking is the indicator of creative potential [64]. One of the most widely used divergent thinking framework is the Torrance Test for Creative Thinking (TTCT) [2, 66, 72, 80]. The TTCT identifies four indicators of divergent thinking: fluency, flexibility, elaboration and originality. Fluency represents the ability to generate a large number of ideas in response to a problem. Flexibility relates to the categories of ideas (breadth or span of ideas). Elaboration consists of the amount of detail associated with an idea or concept. Finally, originality is the extent to which an idea is uncommon, remote and clever [64, 65, 85].

Externalization, Tangibles and Metaphors

During DT workshops, design tools, both tangible and digital, help participants externalize their ideas [40, 41]. Externalization refers to “both embodied interactions with external artefacts, [and] the process of making internal representations external” [19, p. 31]. Externalization serves four key functions [19, 21]: 1) *informational*, i.e., communicating and sharing an idea; 2) *formational*, i.e. “helping to bring an idea into being” [21, p. 114]; 3) *transformational*, i.e., supporting and stimulating the backtalk [68]; and *transcendental*, i.e., articulating, manipulating and structuring ideas as well as triggering new concepts and insights.

Tangibles have been found to facilitate externalization [19], support a design team communication and collaboration [84] and stimulate creativity [38, 50]. By tangibles artefacts we mean any physical objects that can be handled in the real world, in contrast to virtual or digital objects. In this paper we are specifically interested in tangibles that carry a meaning of their own, like a deck of picture cards, toys or mini figurines that can be assembled into “visual sentences” or narratives during the course of a DT session. These types of tangibles generate new ideas quickly with limited effort or creative abilities. Tangibles engage us through sight, touch, smell, and motion, mobilizing tacit knowledge [38].

Furthermore, tangible artefacts help keep “creativity open” during divergent thinking: they provide a certain level of ambiguity and flexibility, while written descriptions tend to be more precise and “closed”. It appears that designers who relied on tangible representations generated better designs and had fewer design fixations [83, 89], perhaps because tangibles appear to “*reduce the cognitive workload, expand critical thinking and communication*” [89, p. 131] and “*build knowledge through action*” [17, p. 31].

Tangibles support externalization of new ideas through the use of metaphors. Metaphors are frequently used in DT workshops to generate new and valuable ideas since they can stimulate imagination, reduce reliance on the past, enlarge the field of reference as well as increase sensitivity to others [54], for experienced and novice designers alike. They can magnify designers’ “ability to envision experiences outside of their own” [54, p. 933].

Metaphors play a fundamental role in divergent thinking [57, 58], as they not only guide reasoning but also enhance creativity [53, 71].

“Metaphors and materials are important vehicles for communicating complex concepts and ideas and designers can point to sets of extraordinarily rich visualizations in their conversations” [38, p. 75].

They are used to augment the cognitive capabilities of designers and teams [10, 11, 73].

Paper-Based Design Tools and Sketching

Paper-based tools, which are often the design tool of choice, offer many key qualities, as they are inexpensive, tangible, flexible, easy to use, lightweight, and can be manipulated in space [21, 34, 41]. Paper-based design tools (paper and pen, chalk and other drawing and writing tools) can facilitate the designers’ reflection as they can be revisited, rendering this knowledge into a shareable form [3]. In DT workshops, paper-based design tools are often used for sketching [14, 21, 55].

Hand-drawn sketches are quick to make, their inaccuracy and ambiguity can favour alternative interpretations and meaning [33] as well as open creative flexibility [30] supporting ideation participants in externalizing their still nebulous idea [19]. Its ambiguous nature allows to see more in a drawing than what its author has actually put in, delivering at times surprise new meaning or “backtalk” [68, 88]. A sketch can be erased, modified, built upon in iterative waves following the design process. Drawings and words are used in sketches to simplify the content and meaning as well as to focus on given aspects of an idea or concept [29, 30].

However, as mentioned above, one major limitation is the fact that most design novices are reluctant to sketch, especially in collaborative settings [9, 76]. Booth and colleagues [9] have identified 8 factors that inhibit sketching, ranging from personal inhibition (perfectionism) [59], skill-set inhibition [63, 87], and social inhibition [35] to comparative inhibition (caused by the presence of a superior sketcher or recent exposure to a high-quality sketch or drawing) [18]. This issue should be of concern for both practitioners and researchers as design novices play a central role in the DT process and could seriously hamper its effectiveness [23, 45, 90]. We are looking at alternative tangible design tools to overcome this limitation and to stimulate design novices’ divergent thinking.

LEGO® and Play

The LEGO® system is made of figurative and abstract 3D physical pieces with which to construct things and tell stories [4]. The studies involving LEGO have recognized their intrinsic materiality and affordance [75], their low learning curve, low-skill requirements as well as their limited need for preparation or planning [1]. Through the variety of forms bore by LEGO pieces, individual participants and teams can access a wide range of metaphors to explore new ideas [43, 67]. Gauntlett [28] has observed that LEGO could more easily represent and communicate larger, more varied range of ideas, concepts and meanings than could pen and paper.

Moreover, LEGO pieces are said to stimulate connection-making, i.e. ‘hands-on, minds-on’ connections [51]. Manipulating LEGO pieces immerses participants in an active state which stimulates various ways of thinking, acting and expressing. As they assemble the pieces, they connect old and new knowledge, thus actively developing new ideas [28, 60]. Youmans [89] argues that physically interacting with a design medium and ‘getting your hands dirty’ appears to improve the originality and functionalities of creative designs.

LEGO pieces are associated with playing and playfulness: “there are cues embedded in [LEGO pieces] that signal that a space, a thing, or a collective are there to play” [70, p. 7]. Regarding play, Bateson and colleagues [6-8] have shown that individual playfulness stimulates creativity and that “play is a generator of novelty” [6, p. R15]. Playing can help create a protected, free-thinking and non-judgmental environment and, in such an environment, individuals are usually more motivated, they relax and free up; playing lowers self-consciousness, shame and responsibility [6, 7, 27]. It can also help individuals break away from established patterns of thoughts and habits which might influence them consciously and/or unconsciously and thus generate more creative ideas as there is no right or wrong answer in playful contexts [8].

Given that elaboration, fluency, flexibility and originality are normally recognized as key components of divergent thinking [64, 73, 80] and since LEGO pieces offer affordances said to “make them significantly more useful than anything else” [29, p. 6] to support creative thinking, we therefore up-hold the following hypotheses:

H1: In a collaborative setting, non-designers, using LEGO® for the early ideation phase of an HCI project, will deliver interface proposals showing greater divergent thinking than when using pen/paper.

H2: In the same setting, non-designers who experience a LEGO-focused warm-up will deliver LEGO interface proposals showing greater divergent thinking than those who have not.

METHODOLOGY

Experimental Design and Protocol

To test our hypotheses, we have conducted a comparative lab experiment, with between subjects mixed factorial design. The two factors were the medium (pen/paper vs. LEGO) and the preparation to the tasks (LEGO-focused warm-up vs non-LEGO warm-up). The experiment was conducted with 44 participants (MBA/IT professionals; average age: 26,5 y.o.; all design novices), randomly paired in 22 dyads, who carried out early ideations of two web interfaces, one using pen and paper (to draw or write with as they chose), the other using LEGO pieces. We used dyads for ecological validity, to replicate the collaborative setting of DT sessions. This experiment was designed upon the prior experiment by Lesage and colleagues [52], with the exact same experimental design except for 2 parameters: in this study, the tasks were realized collaboratively in teams rather than individually and the warm-up activities were different.

User Personas - Teams were asked to design the landing pages (and, or other platform if deemed necessary) within a healthcare portal for two specific personas, first Joelle, a healthcare patient and then Claude, a pharmacist. Joelle and Claude were presented through video testimonies (1 min 30 sec each), in order to establish clear users’ needs for the proposed pages and to lower participants’ reliance on their own (uncontrolled) experience. The persona videos were played twice to help participants remember the information; the participants were instructed not to take notes while listening to the testimonies to ensure they did not start ideating before engaging with the tool, to ensure that the same experimental conditions were allotted for either tool.

Tools description - The pen/paper toolset was composed of different sizes and colours of sticky notes, pens, fine-tipped & bevelled highlighters, colourful markers and felt-tips. The LEGO toolset consisted of various sizes and shapes of regular LEGO, DUPLO® (i.e. LEGO for toddlers), plates, mechanical and architectural pieces as well as mini-figures. It did not include anything resembling webpage objects, in order to help novices, resist the temptation to quickly converge to a solution. LEGO pieces were selected to test our hypothesis because it 1) challenges participants to get out of their comfort zone, step back and take different perspectives, and 2) to induce playfulness, which triggers divergent thinking [6]. No writing material was provided with the LEGO toolset. A preparation video (1 min) presenting each toolset was viewed before each warm-up. In the pen/paper video, participants were encouraged to sketch their interfaces.

Experimental Task Procedure

Data Collection

Warm-up - The two conceptual ideation rounds were preceded by a 7 min creative-thinking warm-up exercise to break the ice between the participants who did not know

each other and to give them a first collaborative experience. Twelve teams did a 7 min Marshmallow Challenge [86] (i.e. the non-LEGO warm-up) and ten teams were asked to collaborate by first, building a LEGO house together and then, to complete a given storyline where the setting was the LEGO house they built.

Ideation tasks - To reduce learning effects, teams were randomly assigned to doing their two ideation tasks in either a paper/LEGO or a LEGO/paper sequence. Participants were given a 15-minute time limitation for the ideation activities, which seemed acceptable; a number of dyads finished before the time was up. After each ideation task, the team was asked to present their interface proposal in detail by pointing out and naming each element, explaining its function and what to expect when interacting with it. After the second ideation was done and described, participants were asked to individually complete a short questionnaire about their experience with the two different tools.

The data considered for this study included the two interface proposals (see Figures 1 and 2 for representative proposals), the video recording of their verbal description of each interface proposal and the answers to the final individual questionnaire.

Figure 1. Example of an interface proposal developed with the pen/paper toolset, showing a drawn calendar in upper right.

Figure 2. Example of an interface proposal developed with the LEGO toolset, using a hub metaphor for the site and a hologram doctor consultation platform (top right corner).

Creativity Assessment

The key to creativity and innovative proposals in DT is the divergent phase. The 44 interface proposals (i.e., two per dyad) were assessed according to the TTCT framework. To operationalize the assessment of divergent thinking, we relied on the TTCT's four key indicators: fluency, flexibility, elaboration and originality.

The first three indicators were assessed quantitatively by counting the number of ideas (fluency), the number of categories of ideas (flexibility) and the number of elements describing an idea, i.e., the number of items associated with one meaning (elaboration), cross-referencing two sources: video recordings and photos taken of the interface proposals. To do this, two research assistants, equipped with the evaluation modalities were asked to separately count these three indicators for the 44 interfaces.

Most interface proposals had multiple ideas, i.e. types of content, functions, or interactions. For example: a page could have a login area, information area about the patient's health, a current medication list, a calendar and so on. If a calendar had three functions it could do, the calendar + three functions added to four ideas, but only one category of idea.

Torrance [77, 78] gave very clear directions as how to count elements, which boil to counting every semantic element of a drawing. In a sketch, every element is there because the author meant it to be there. With pre-assembled figurative pieces, we latched onto the semantic units, i.e., using video recording of the verbal explanations of each interface proposals, we counted every item the team regarded as a semantic unit. For example, a LEGO figurine might have 2 legs, 2 arms, a head, a helmet, if the team referred to the figurine as "the doctor" we counted it as 1 element. If they put a sword in its hand, and explained that the sword was "like medicine" we counted the figurine + sword as 2 elements.

To calibrate the counting, the two research assistants reviewed their ratings side-by-side and, after each counting, compared their scores. When there were discrepancies, they went back to the data, counted together, discussed the differences until they agreed on the count. They continued until they reached consensus on all entries. Through the 44 interfaces, 1440 ideas, 484 categories and 2610 elements were accounted for.

Originality, the fourth indicator of divergent thinking, was assessed qualitatively through subjective scoring [72] by two experts as judges, two UX designers, blind to our hypothesis. The fact that DT is rooted in disciplinary knowledge made us choose to assess originality through subjective scoring [2, 72]. We layered it with Guilford's three indicators of originality [65, 79, 85]: *uncommonness*, i.e., infrequent and pertinent; *remoteness*, i.e., straying away from the obvious; and *cleverness*, i.e., smart, insightful, fitting, and, or humorous. Before launching into their evaluations, the judges felt they needed to be more specific about these three indicators and how to unmistakably recognize these in the interface proposals. The two judges brought a professional UX lens to this exercise; each indicator was further described as follows.

For *uncommonness*, the judges rewarded unique ways to respond to Joelle or Claude's needs, putting extra weight on the pertinence. For example, Joelle mentions in her testimony that she would like a calendar on her homepage; not surprisingly, most every team put a calendar. The calendar idea was not automatically dismissed as "common", instead it was rated according to how the calendar was treated to respond to Joelle's needs. Here's a good example from one team: "*Joelle seems to organize her relationship to the healthcare system in terms of day-to-day interactions, so we linked a maximum of info to her calendar; adding the app for her mobile phone, so she can get notifications and guidance while at the hospital*".

For *remoteness*, the judges paid special attention to the level of abstraction in the verbal explanations as well as in the visual representations, i.e. from conventional user interface (UI) layout to a more metaphorical interpretation of the solution space. They felt that, at an early stage of a project, any proposed interface layout was going to evolve a lot and the early proposals would quickly disappear, with no lasting effect. On the other hand, a more evocative suggestion had more chance to turn into a guiding metaphor throughout the development of the design solution. A good example was an interface organized as a cartwheel, with the user at the centre, each spoke leading to a category of information or interaction; the whole solution space was thought of as a "hub" for the user (see Figure 2). A proposal that simply replicated UI layout conventions for no particular reason (e.g. "because that's how it is done") was seen as prematurely closing the solution space. This position from the judges is in line with later expansions of the TTCT whereby abstractness and resistance to premature

closure were added as predictors of creative achievements [78].

For *cleverness*, the judges felt it could be compounded with the previous two, for example when the implementation of an idea is insightful, smart or surprising, or when the use of a less than obvious metaphor really captured the heart of the personas' needs, showing an incisive understanding of the problem. Cleverness is a quality that seems to augment the power of the first two indicators.

The two UX expert rated, separately, each interface proposal for each of the three indicators on a scale of 1 (e.g., poorly clever) to 5 (e.g., highly clever). The three scores were added into a score over 15. The ratings from the two judges were then averaged into the interface's originality score.

Data Analysis

Once all 44 interfaces have been rated for the four indicators i.e. fluency, flexibility, elaboration and originality, each score was adjusted to fit on a 10-point scale. Then the four indicator scores, for each interface were averaged into a single divergent thinking score per interface proposal. This overall score was used for the overall divergent thinking comparative analysis (pen/paper vs. LEGO). Then another round of comparative analyses was done, one indicator at a time.

In a post-hoc analysis, we also looked at the correlations between indicators within each tool, for LEGO and for pen/paper. The purpose was to better understand the relationships (or the dynamics, if any) between number of ideas (fluency), breadth of category of ideas (flexibility), how elaborate is an idea (elaboration) as well as its originality, for each tool. Data analysis was conducted by means of SAS software, using a linear regression with mixed model, a 2-tailed p-value and a significance threshold of $p < 0,1$.

RESULTS

When comparing the interfaces produced with both tools, the LEGO interfaces gathered significantly higher overall divergent thinking scores than the paper interfaces ($p = 0,08914$; T-test), which confirms our main hypothesis (H1, supported).

Moreover, looking individually at the four indicators (Table 1), we found that ideas (i.e. fluency) and categories (i.e. flexibility) counts, as well as originality scores show no significant differences between pen/paper and LEGO interfaces, but interface proposals developed with LEGO involved a significantly higher number of elements (i.e. elaboration) than paper interfaces did ($p < 0,0001$).

Variables	Difference-Tool	N	Z	p-value
# Ideas	Paper - LEGO	22	7,5	0,7909
# Categories	Paper - LEGO	22	-21	0,2957
# Elements	Paper - LEGO	22	-107,5	< .0001
Originality	Paper - LEGO	22	8,5	0,7138

Table 1. Results for the four divergent thinking indicators pen/paper vs. LEGO.

The **correlations between indicators** in pen/paper (see Table 2) and LEGO (see Table 3) are as follows:

When using *pen/paper*, our data yielded only one significant correlation: interfaces with a higher count of ideas (higher than the median ideas count for the group) seem to have a higher count of categories (again, higher than the median category count for the group) ($p = 0.0604$).

Variable	Split by	N	Medians	p-value
# Elements	Ideas	22	17,06 – 16,6	0,7861
# Elements	Categories	22	5,5 - 5	0,6813
# Elements	Originality	22	9,67 – 9,56	0,9908
# Ideas	Categories	22	6 - 5	0,0604
# Ideas	Originality	22	10 - 9	0,8057
# Categories	Originality	22	10,5 – 9,5	0,3223

Table 2. Results for correlations between the four indicators when using pen/paper.

When using LEGO, our data showed five significant correlations: interfaces with 1) a higher count of elements (higher than the median element count for the group) seem to have a higher count of ideas (higher than the median idea count for the group; $p = 0.0081$), 2) a higher count of categories (higher than the median category count for the group; $p = 0.0056$) and 3) a higher originality scores (higher than the median originality score for the group; $p = 0.0182$). Interfaces with 4) a higher count of ideas seem to have a higher count of categories ($p = 0.0035$). And lastly, interfaces with 5) a higher count of categories seem to have a higher originality score ($p = 0.0848$).

Variable	Split by	N	Medians	p-value
# Elements	Ideas	22	19 - 10	0,0081
# Elements	Categories	22	6 - 4	0,056
# Elements	Originality	22	6 – 3,5	0,0182
# Ideas	Categories	22	7 - 5	0,0035
# Ideas	Originality	22	10 - 9	0,1593
# Categories	Originality	22	10,5 – 9,5	0,0848

Table 3. Results, for correlations between the four indicators when using LEGO.

Taken together, these results suggest that for interfaces co-designed with LEGO, when the elements are numerous, the three other indicators also get high score; these indicators

appear to be correlated. With pen/paper, the only correlation is between high number of ideas and high number of categories of ideas.

Lastly, when comparing the LEGO interface proposals, those produced by teams who went through a LEGO-focused warm-up show no significant difference (see Table 4) from those who had a regular warm-up (H2, not supported).

Tool	Variable	By	N	p-value
LEGO	Originality score	Reg. warm-up – LEGO warm-up	22	0,561
LEGO	# Categories	Reg. warm-up – LEGO warm-up	22	0,2959
LEGO	# Ideas	Reg. warm-up – LEGO warm-up	22	0,3894
LEGO	# Elements	Reg. warm-up – LEGO warm-up	22	0,875

Table 4. Results of the Wilcoxon signed rank test between LEGO-focused warm-up and regular warm-up

DISCUSSION

The purpose of this study was to find a way to help design novices, or non-designers, engage in the divergent phase of design thinking (DT) workshops, considering that most novices are reluctant to use sketching to share their ideas during co-design. We proposed that a tool like LEGO pieces could replace the current default situation which is to use sketching material, paper and pen to write ideas on sticky notes. Indeed, the use of LEGO might help design novices overcome some irritants of sketching identified by Booth et al. [9], e.g. skill-set or situational inhibitions. Furthermore, unlike sketching, LEGO levels the playing field by diminishing the “good” vs. “bad” way of using design tools.

Our results suggest that, during interface ideation with design novices, a tangible, figurative and metaphorical tool, like LEGO pieces, supports divergent thinking better than concepts written on sticky notes. These results are the same with or without a LEGO-focused warm-up. Yet, in this study LEGO and pen/paper interfaces delivered similar levels of fluency, flexibility and originality. The major difference between the two tools is that LEGO delivered significantly more elaborate visual representations, involving a higher number of visual elements.

Why Elaboration is Key for Divergent Thinking in DT

As seen above, elaboration is an indicator within Torrance’s Test for Creative Thinking (TTCT), designed to assess creative thinking potential and abilities. The TTCT assesses an individual’s creativity potential by, firstly, evaluating the levels of four creativity indicators (i.e. fluency, flexibility, elaboration and originality) through visual figurative representations, i.e. drawings, generated by this individual. Subsequently, the evaluation from the four indicators is

inferred to the individual to establish his/her creative thinking potential. Thus, the TTCT uses visual figurative representations as proxy to assess an individual's creative potential. By applying the TTCT theoretical framework to interface proposals, we are borrowing from the TTCT the fact that this test uses visual figurative representations to infer creativity. However, in the present study, interface proposals, which are visual figurative representations generated collaboratively, are assessed for their own intrinsic creative potential, without making inference to the creative potential of its authors. Doing so, we sought to measure the levels of creativity of design solutions, i.e. interface proposals, to compare the impact of the two different tools that were used.

In later versions of the TTCT, Torrance organised the main indicators according to two creative types: innovative creativity and adaptive creativity [37, 61, 77]. Fluency and originality are related to innovative creativity—a transformational, and expressive type of creativity—and elaboration is related to adaptive creativity. For some researchers, adaptive creativity is seen as “lesser” creativity type in comparison to innovative creativity [46-48]. Researchers will often leave out elaboration when testing for creativity, focussing instead on fluency and originality alone [64]. This may be true when considering an individual's creative abilities but, in the present study, we are looking at the creativity level of outputs (here, interface proposals) generated through the design process; and the elements detailing the interface proposals play a central role in that process.

Indeed, in the design process, visual elements are essential as they tell us how a concept is elaborated, how it might take form. Elements, i.e. the extra visual semantic units elaborating a concept, give a hint of how an abstract idea could turn into an implemented solution. In short, elaboration is essential to turn creative ideas into innovations. The elements can chart the path from concept to prototype and eventually to solution. During a DT workshop, these elements provide a great richness of information, both in terms of depth and breadth that will allow co-designers to: 1) better understand the concept as a whole, 2) have more information to bounce back and build upon, and 3) more easily move from the conceptual level to the concrete realisation. The purpose of DT is to involve the whole project team into the act of creatively grounding ideas into innovation.

Designers are trained to think creatively (divergently) about how an idea could be eventually implemented. In a given iterative design cycle, co-designers will propose an idea and play/juggle with it to see if it could potentially become a realistic solution. This “playing” around with an idea, which is often scenario based (e.g. *Joelle could do this with...; Claude wouldn't have to ... anymore*), is not a convergent activity per se but rather a divergent projection into the problem-space to see if the idea is worth pursuing.

Thus, all these projections conducted by design teams can open the way towards creative actionable solutions. Therefore, in divergent thinking, elaboration details and suggests how an idea could potentially be shaped and become reality.

Elaboration is not specifically divergent or convergent, but when used in the divergent phase, the extra semantic units describing a concept help project this concept into new or alternative meanings and propositions. It is not a lesser form of creativity; on the contrary, it is where some of the smartest form of design creativity actually takes place; where cleverness (i.e., smart, insightful, fitting, and/or humorous) emerges, where remoteness (i.e., straying away from the obvious) might strike.

Moreover, in early conceptual ideation while in divergent mode, the richer the elaboration the more the team is likely to build a strong shared understanding.

Why LEGO Supports Elaboration and Openness

Sketching is recognised to be one of the best ways to support early collective conceptual ideation, as it is apt to support plenty of elaboration. But for teams who would rather not sketch, our results suggest that a figurative toy-tool like LEGO could be a substitute. LEGO forces DT participants to express their ideas through concrete metaphors, thus keeping the solution space open by suggesting indirect ways to express their newly formed concepts. Even though sketching and LEGO do not cognitively function the same way, they fulfil the same goal: to open the solution space, or resist closing it prematurely. Actually, our results suggest that LEGO might be a better substitute for sketching than pen/paper as currently used.

The fact that LEGO requires participants to think through metaphors may be a good thing for novice designers: it helps them avoid falling back on their knowledge domain and instead helps them keep the solution-space open [22, 36]. Our observation of their use of pen/paper suggest that they are in a hurry of “solving the problem”, at least on a conceptual level (i.e., find an idea for each identified needs of the personas). A number of teams have quit the ideation process before the allowed 15-min period because they had one idea for every need.

In the paper interface proposals, participants did not wonder how these ideas would take form. Even if participants were encouraged to sketch with their pen/paper toolset, yet, all teams chose to write on post-its and A3 sheets, sometimes linking written concepts with arrows (Figure 1 is representative of most pen/paper proposals: there was no sketching). So, what the literature had observed [9] was spontaneously replicated in our study.

With the LEGO interface, although they had the same hurried approach, the LEGO pieces kept their proposals open. For example, nearly every team proposed to set a calendar to their interface proposals. In pen/paper, the

calendar was often represented by the word “calendar” jotted on a sticky and placed “where the calendar would be.” With LEGO, the teams had to rely on a visual metaphor to express the idea of calendar. A few teams used a LEGO fishing net; they said they were looking for something “grid-like”; but once they handled the fishing net, they would often think of overlaying the calendar with networking functions. Comparing the word “calendar” on a sticky to a LEGO fishing net, is an example of what it means to leave a proposal open. The fishing net-as-calendar holds many levels of latent meanings, keeping the solution-space open (see Figure 3). The word “calendar” has fewer alternate meanings, thus does not stimulating co-designers’ imagination as much.

Figure 3. Fishing-net-calendar-turned-network-hub

Why LEGO Elaboration Generates Original Ideas

Non-designers in DT sessions maybe design novice, they are nevertheless experts in some aspect of the project they are on. In this study, participants were novices to design but had general expertise as users of the healthcare system, which in part fuelled their two ideation sessions. In post-hoc analyses, we looked into correlations between indicators within each tool use. We found that with pen/paper the only correlation was between a high count of ideas and a high count of categories. Fluency (number of ideas) and flexibility (categories of ideas) have in common that they account for ideas, and ideas alone. They are both focused on conceptual activity (with no consideration about HOW these ideas could take shape). They stay in the concept domain [28, 44].

Furthermore, our results show that teams had as many ideas (and categories of ideas) with pen/paper than with LEGO. But with pen/paper, the ideas they had did not lead to higher elaboration or originality. Whereas, when these teams used LEGO, the interface proposals that had high element counts, also had high counts of ideas, high counts of categories of ideas as well as high originality scores.

With LEGO, not only was elaboration higher in terms of the number of elements used to detail an idea, but

elaboration was different. In pen/paper elaboration was descriptive; with LEGO, it relied on metaphors thereby potentially triggering originality’s uncommonness, remoteness and cleverness. The LEGO pieces that were available to our participants did not come from healthcare or UI design related LEGO sets. Therefore, any piece used was going to be (strongly) remote from the obvious. But the most interesting divergence happened when a metaphor cut through the obvious to reach a surprisingly insightful way to respond to the persona’s needs; then the LEGO elaboration really enhanced the originality of the design proposal.

Participants who preferred paper emphasized its directness while those who preferred LEGO repeatedly mentioned that it “forced [them] to think in a more creative way” (e.g. P08), that the figurative aspect of LEGO inspired them (e.g., P11, P17). Thus, an explanation as to why a tangible design tool, such as LEGO, yielded more divergent results appears to be linked to the figurative and metaphorical nature of the LEGO sets used.

Finally, it was interesting to see that the LEGO-focused warm-up had no significant impact on the level of divergent thinking on any interfaces that were produced. This suggests that LEGO does not need framing or warming up to be integrated into DT workshops. The learning curve of LEGO is understandably low and short, and its construction potential is near limitless.

Implication for Practitioners

Before starting to use LEGO, it is crucial that non-designers understand the importance of the divergent phase and how it will proceed. More specifically, it is essential that they understand that 1) premature closure might be detrimental to the level of innovation to be reached and it is better, at this point to keep the solution-space open; and 2) LEGO is better than writing to trigger and support divergence by keeping the solution-space as open as possible. LEGO helps generate alternative ways of elaborating solutions while providing a greater richness of semantic details for co-designers to understand and to react to.

In our own practice, we found that talking about LEGO’s metaphorical nature gets us nowhere with novice designers; it is too theoretical. On the other hand, stressing the narrative potential of LEGO and emphasizing that LEGO helps create and tell stories helps adoption. Presenting LEGO as a tool that can reframe potential solutions in a different “interaction story” leads to a better understanding of how LEGO can be used in the co-design of HCI projects. LEGO mini-figures definitely help turn design proposals into narratives.

The second main implication for the HCI design practice is to have further adapted the TTCT to assess and measure signs of divergent thinking in design representation, with an expanded understanding of the notion of originality and

how uncommonness, remoteness and cleverness is embodied.

Uncommonness in a UX perspective rewards unique and infrequent ideas, by putting a lot of weight on the pertinence of a proposed concept. *Remoteness* pays attention to the level of abstraction in the verbal explanations as well as in the visual representation (from conventional UI layout to a more metaphorical interpretation of the solution-space). In HCI design, the temptation to replicate a typical UI layout may close the solution space prematurely, whereas an evocative proposal may turn into a guiding metaphor throughout the development of the design solution. *Cleverness* and insight are qualities that can be compounded with uncommonness or remoteness, adding a spark of surprise, delight or humour to a proposed concept. Cleverness is a modifier, it modifies the light shed on an idea, bringing it up a level. It often takes its inspiration from being human-centred.

Limits of This Study and Next Steps

In this study, our focus has been limited to the resulting artefacts, the interface proposals, made by the 22 teams. We have not considered the full impact of collaboration on the resulting interfaces, nor the experience or the individual creative styles of each participant. Collaboration was not measured per se, the purpose of using a collaborative experimental setting was to assure greater ecological validity and to help the researchers potentially get insights from hearing their verbal exchange.

In popular belief, creativity is often associated with unaided individual minds working in isolation. However, in reality, human creativity is social and usually comes out of interactions and collaboration within a diverse group [24, 49, 69]. Since understanding of the problem, its context and desired approaches may differ, collaboration and communication may pose a challenge. To overcome this challenge, a design team needs to develop a shared understanding of the content (what to do) and the process (or how to proceed) [49]. In turn, to develop a shared understanding, members of a design team will have to develop a knowledge system in which the meanings of ideas and objects can be discussed and debated constructively [24]. Fischer and colleagues [24] have shown that boundary objects, such as LEGO pieces, can be used to support communication and developed a shared understanding between diverse team members. Since LEGO seem to have potential to quickly produce elaborate concepts, perhaps it is also suited to quickly promote shared understanding within a design team.

CONCLUSION

Tangible figurative tools, like the LEGO system, better support divergent thinking than pen and paper (when used to write words down and stick them on a whiteboard), because the latter keeps the design conversation conceptual

(in the realm of ideas), and LEGO introduces suggestions on how these ideas could take shape (metaphorical suggestions). Using LEGO forces participants into adding more details to their ideas, thereby potentially augmenting their originality.

Furthermore, looking closer at the implications of using the TTCT theoretical framework to assess outputs of the design process, our results highlight a different perspective on one of the TTCT indicators: Elaboration. When assessing creativity types, elaboration is often seen as lesser indicator of creativity, and often even not considered when testing creativity. Used to assess visual representations of early ideation, elaboration is an important sign of design creativity. Elements detailing an idea represent the projected path to a prototype and later to a definitive solution. Thus, LEGO appears to have greater divergent potential. By using tools that help express new ideas and how these could take shape, non-designers acquire a way to further their participation into the design of solutions, more so than they would by writing words on paper.

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