A proposed technique for ideation through artifact shape deviations

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ABSTRACT
This paper proposes a new ideation technique for how to ideate using sketching and a generative design system based prototype tool. The technique is aimed to support ideation through the exploration of design shape deviations. The tool generates 3D model artifacts with variations in their shapes. The overall shape and deviations are based on a design concept specified by the user of the tool. These design artifacts are then used as a means to rediscover one's own design concepts through the theory of estrangement. A study was conducted where university-level design students tested the technique in a scenario where they were tasked with ideating product design solutions. The performed study (along with post-study interviews) revealed promising results where participants of the study described their experiences as fun and interesting. The design outcomes of the study display how participants worked and iterated on their conceptual artifacts. They explored different and new angles of the design space relative to their concepts by using the generated design artifacts. This may suggest that this technique, using computer-generated concept deviations can be a successful way of supporting ideation by expanding on one's design concepts, rediscovering concepts, moving beyond obvious solutions and iterating design concepts.

Author Keywords
Ideation; generative design; estrangement; creativity; mixed-initiative systems.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Essential to the work of designers is the capability to generate ideas. Ideation is the part of the design thinking process where one focuses on generating ideas [4]. There are many different techniques and methods of spurring ideation and generating ideas. One of the most common and arguably most cross-disciplinary ideation technique is brainstorming. The purpose of brainstorming ideation is to generate as large a quantity of ideas as possible without judgement [4,10,17]. Another technique most creatives should find familiar is sketching. Sketching is where ideas are visualized as representations through drawings, often drawn quickly with only the major details [8]. Sketches can serve many purposes; they can serve as documentation of ideas, as a way of sharing ideas with other people, and as documentation for the person drawing themselves [8], i.e., not having to keep all ideas in one's head. Sketches can also serve as a way to generate, explore and evaluate ideas [8].

The evolution and advancement of the computer and other modern technologies have allowed for the design of added computer-assisted techniques. Voice recordings are such additive elements that can assist and enrich sketching activities. Final sketches do not reflect the entirety of the design intent of the person drawing, but voice recordings help convey that intent more thoroughly [8].

This paper introduces and documents the creation and development of a computer assisted ideation technique. The technique is based on the theoretical concepts of estrangement and the technology frameworks of generative design systems to facilitate ideation. The technique use sketching activities to generate concepts/ideas, in combination with a digital prototype tool that helps iterate on the sketched concepts, generating new and different alternatives and deviations of the sketched concepts. The prototype tool generates these concepts in the form of 3D models within a software environment. This means that any ideas or concepts sketched by the user of this technique on paper need to be remade as a 3D model in that software environment. This is required so that the prototype tool can read the ideas or concepts and generate new alternatives and deviations from them. The prototype tool is intended to elicit the generation, exploration, rediscovery, and iteration of established ideas/concepts. The prototype tool adopts and repurposes the software technique Generative design to generate these concept variations/deviations. The technique is primarily aimed for application within the field of HCI, during the conceptualization of physical tangibles. Its application, however, intersects that of product design and industrial design, as these industries also deal with the conceptualization of tangible artifacts. The technique is however not directed at producing production-ready artifacts. Rather they serve as product inspiration and rediscovery. Therefore, the artifacts produced by the tool can be "impossible shapes", i.e. shapes that cannot be physically realized.

Additionally, this paper documents how the proposed technique was researched; where its effect on ideation was tested through a user study. The study was conducted in two sessions. Both sessions were set up as design workshops, where participants of the study tested the technique with myself (the author of this paper) leading them through the technique. The study was performed with a total of three participants, who were all students studying design at a university level. The function of the user tests was to see how the technique affects ideation while performing creative work tasks and additionally for users to provide feedback with both their experiences and also ways to improve the technique in the future.

The overarching aim and research question of this study and paper is; *how this technique, adopting and repurposing generative design system procedures can assist the ideation stage of the design proces*s. Additionally, is to make a case for why such a technique is of benefit to those performing design work, primarily in HCI.

Of note is that any discoveries found throughout this paper can only be preliminary. As the small number of study participants cannot determine any unequivocal results.

BACKGROUND

During this section, relevant technologies and theoretical frameworks are introduced and explained. This helps provide an understanding of the relating subject areas of this paper and how they are being applied in relation to the creation and study of the proposed technique.

Human-computer creation

Before exploring the creation or testing of the developed ideation technique it is relevant to understand how humans and computers coincide in relation to one another when co-creating artifacts. Mixed-initiative systems are such systems that rely on both computer and human in the process of designing artifacts [15]. However, the process and underlying workflow of creating artifacts with the assistance of computers can differ. Systems can be more or less driven dominantly by either human or computer. On one side of the spectrum lies Computer-aided design (CAD), where the human performs most of the work [15]. The systems support the human with tools in their work, performing specific activities or actions by itself when the human directs it to. On the opposite side of the spectrum are systems where humans provide less input [15]. Here the method of interactive evolution is common [15]. The systems work more independently, and human input is more likely to guide the system in smaller increments as the computer performs the majority of the work.

Generative design

Generative design systems are programmed computer systems. They are commonly used in engineering and industrial design but has in more recent years become a dominant force in architectural work [16]. Generative design systems are generators, i.e. that they generate some sort of content. The purpose of generative design generators is to automate parts of the design process [7, 9, 13, 14]. Their system function is generating alternative solutions, ideas or concepts to one that is predefined by the user. These systems thus require the human user to input a base design concept, which will guide the system in generating the variants, i.e. the alternative design concepts based on the input design concept [7,9,13, 14]. These systems can be classified as mixed-initiative systems as they require both computer and human to function.

Further, generative design is an iterative and repeating process. After design (concept) artifact(s) are generated (meaning that one cycle of generation has been performed) the human user interprets the artifacts, makes changes to any parameters or other forms of control present in the system. They can also update the base design input to further guide the generation of new artifacts in a certain direction. The process is repeated, often multiple times, where new design alternative(s) are generated. Every new generation cycle is based on the updated conditions of the previous [9,13,14]. The process is repeated until the human user has reached their goal with the activity.

A common theme among generative design systems seems to be (as observed during my research) that many systems are based in CAD software environments. Additionally, the design artifacts being generated seem to in most cases be 3D models. The prevalence of 3D model generative design systems can be explained by the industries where they are commonly used (industrial design, product design, and architecture [16]). As these industries deal with artifacts in physical 3D space, they use generative design systems that generated 3D model artifacts. Additionally, one common goal for using generative design systems is to, through the generation of artifacts, uncover the "optimal" design solution(s). Exemplified by architectural generative design research by Caldas et al. [7]; their "optimal" solutions were the most energy-efficient. The particular system they used is one developed for the very topic of energy efficiency, and also required a large degree of user input over the generation conditions through parameters/constraints [7]. One example is how their base design input was a 3D model recreation of a room existing in reality [7]. They generated new alternative room designs from that base 3D model, where the window placements differed. The displacement of windows facilitated the discovery of the optimal placement in relation to the amount of sunlight the windows let in [7].

Researchers on the topic of generative design often concern themselves with the development of new algorithms that are by some metric superior to the one before it. Such research of development and testing of a new algorithm was performed by Khan et al. [13]. They developed a new algorithm, which they compared to an already existing algorithm. They detailed and tested how their algorithm was superior in exploring variations in 3D model shapes [13].

Although a large set of generative design systems generate and explore 3D models, there are other ways of using generative design. Other implementations and explorations of generative design work can be seen through the likes of Troiano et al., where generative design is used in the generation of alternative color schemes adapted for colorblind people and also in generating hierarchies of user interface menus [19], abstract forms generators [9], 2D shapes [9] and more.

Estrangement

Central to the application of the developed technique of this is paper is estrangement. Estrangement [21] or defamiliarization as referred to by Blythe et al. [5] is where one tries to rediscover designed artifacts through some manner of method or technique. Wilde et al. accomplished this during their research by incorporating the human body in a variety of different methods [21]. Bodily experiences like feel and touch were used to estrange the users with the artifact, often through props placed on the body or as visual stimuli [21]. These experience-driven methods with artifacts fuel ideation with users [21]. Blythe et al. takes a different approach and explains how to estrange oneself to artifacts based more around mindsets and critical concepts [5]. They exemplify looking through the lens of an odd user or analyzing spaces through cultural lenses as ways of enacting estrangement [5].

Estrangement is of relevance for the developed ideation technique and study as it provides a theoretical framework for how artifacts produced by the prototype tool can function as a means of estrangement, leading to the rediscovery of artifact concepts. Additionally, estrangement provides insight into the mental processes of rediscovery which are helpful in discussing how participants designed and explored concepts based on these rediscoveries.

Creativity

The proposed technique functions to elicit creativity to some extent. Another way of putting it is that the technique intends to through ideation, assist the user to harbor creativity– to be creative– to develop creative concepts. Therefore, it is relevant to understand the concept of creativity. Creativity is the capability to generate new ideas [3]. Creativity is also explained as the formulation of “novel and appropriate responses” [1] to a problem that is without a definite answer. Thus, the solution to any problem is considered creative when said solution (in whatever form that solution is, be it a product, artifact, song any or other) is new [1] or surprising [3]. It is not enough for a solution to be different to be creative. For solutions to be considered creative, they need to be considered as valuable and/or fulfill a certain goal in some respect [1]. Further, solutions are creative when people knowledgeable about the area one tries to be creative in sees said solution and acknowledge it as such [1]. Additionally, creativity is identified as the facilitator of innovation, as Howard et al. explain that innovation is impossible without creativity [12]. Creativity is explained to be cultivated through three internal components of the person [1]:

- The process: How people carry out creative work in order to generate ideas [1, 12]. Relevant factors include personal characteristics like how risk-taking the person is, how well they can view problems from different perspectives and break out of conventions [1].
- Relevant expertise: The knowledge and skillset the person has that are applicable to the creative activity [1].
- Motivation: How interested the person is in the creative task. It is explained that the best form of motivation for eliciting creativity is intrinsic motivation. Motivation is affected by what level of enjoyment, passion, satisfaction, personal engagement and how challenging the experience is [1]. Higher motivation leads to higher amounts of creativity.

Creativity can according to these components be seen as largely in the hands of the individual. How well adapted they are to tackle a problem creatively has to do with their frame of reference in regard to their skill set, personality, and mindset. There is however also an environmental component [1]. This is however less relevant here as the interest for this paper is the activities of the person performing the designerly work using the proposed technique.

DEVELOPING THE IDEATION TOOL AND WORKFLOW

Creating the prototype tool

The choice to develop a prototype ideation tool of my own was manifold. To utilize an already existing tool was initially up for consideration. However, while researching existing tools it was discovered that few fulfilled the criteria sought after. These criteria were that the system was to be relatively easy and enjoyable to use and allowed for a fast workflow. Additionally, the intended application of the tool was different from that of “traditional” generative design tools where the goal is often to generate the most optimal solution(s) in the given context of the tool [7,13]. Of interest for my application and goal was to adopt and repurpose generative design technique(s) to support ideation and explore how well the generated artifacts can be of support for further iteration and ideation of design concepts. There was, therefore, a difference between the intended application and that of “traditional” generative design tools. One existing tool did, however, seem promising. There was however no response when the creators of the tool were reached out to.

Designing a prototype tool myself instead of relying on someone else's generative design tool did have its advantages. Being able to tailor, dictate and direct the functionalities of the tool to best suit ideation activities, and change it throughout its development was a valuable asset. It was coded in the scripting language Python. The tool itself is used within another software; the computer animation and 3D modeling software program called Cinema 4D [6]. The reason for this is that the tool generates 3D models, and thus there needs to be an environment where the generated artifacts can be viewed and edited. Additionally, the script is dependent on some internal functions and commands stemming from Cinema 4D.

The underlying ethos of the tool during its development was to spur ideation, through the artifacts it generates. Development was however not always clear-cut. Some difficult questions arose during its creation. Most critical was how the base design should be altered by the tool. Different versions of the tool solved this question in different ways. Earlier versions of the prototype presented multiple generated 3D model design alternatives with very similar characteristics. This was changed rather quickly as some internal testing revealed that having very similar results was not very inspiring to ideate from. Instead, the tool was revised, and the code changed to work more "randomly" i.e.; generate artifacts less alike, the key phrase used was "Generate radical alternatives to the base artifact". This would give the user of the tool more variation to explore when ideating and iterating on their design ideas. Further, later versions of the tool provided more quality of life improvements like improved spacing between the alternatives within the computer environment and the software handling scenarios where the tool is used in unexpected or unintentional ways.

The tool does however remain a prototype. This is for a few reasons. Ideally, the user would have some control over the generation. Some sought after functionalities were discovered during the study, like basic control over how many artifacts should be generated along with UI elements that could provide some clear instructions. As the tool remained a prototype throughout the study and as of this paper; the tool is essentially (to the user) a button they press, and all functionalities happen in the background and are predefined. The one exception being that the user decides the base design artifact which all generated artifacts are based upon.

Outlining and using the technique

The tool itself was designed to work alongside sketching activities while exploring solutions during the ideate mode [4] of the design process. The combination of adopting generative design functionality and the theory of estrangement for ideation exploration provides the basis for the ideation technique. The workflow of this ideation technique is structured as the following:

Step 1 – Paper ideation

The initial step for the user is to begin to ideate. This entails generating ideas by sketching them down on paper. The paper medium allows for quick exploration, expression, and visualization of creative solutions/ideas [8]. Sketching is explained as "quick and dirty" [8], which aligns with the purpose of this initial activity in the technique, to generate ideas. This sketch activity is intended to elicit quick ideation, where the ideas, concepts, and solutions the users have in their minds for a given design problem are expressed and documented. The sketches should be simple in nature, as the next step is to remake the drawn paper sketches into individual 3D models.

Step 2 – Making sketches to 3D models

After having drawn paper sketches until the user has depleted their idea pool, they need to decide what concepts they wish to explore further. These concepts will be the ones the user remakes into 3D models. This is done in the computer software environment of Cinema 4D, where the user creates 3D models for each selected concept/idea/solution. The users have to take their paper sketches and manually model them in 3D. Here is where simple sketches show their efficiency. A more complex and detailed sketch would entail a longer time modeling the concept into a 3D model and less time on actual ideation and iteration of that concept. As per the intent of the ideate mode of the design process; where a wide range of the design space is meant to be explored [4], lingering on a single concept (here drawing and subsequently 3D modeling a larger set of small details) does less to fulfill the goal of the ideation. A crucial driver of this technique is the rapid exploration of design concepts/ideas/solutions, i.e. that the flow of ideation, iteration, and exploration of new ideas/solutions happens at a fast pace. This should ensure that the time one has allocated to ideation is used wisely and that one explores a larger extent of the solution space. The third step of the technique can be initialized when the selected concepts have been remade from paper sketches into 3D models.

Step 3 – Using the prototype tool and beyond

During step 3 is where the prototype tool is used. As the tool is (as mentioned above) that of a prototype, it is restrictive in regard to how much input the user can have. The single aspect the user defines is what 3D model, i.e. what concept– what base design the tool uses to generate new designs artifacts from. Thus, the part of the prototype tool the user sees is a button in Cinema 4D. Selecting the model and clicking the button initializes the generation of artifacts. The tool then works by modifying the selected input base 3D model in various ways, utilizing several deformers native to Cinema 4D, along with a randomizer module which assigns a random number between a set range to each deformer– defining its shape. This procedure is repeated automatically a number of times, resulting in the generation of 11 new 3D models with unique shape variations and characteristics inspired by the 3D model selected by the user. This procedure happens close to instantly and the user is then presented with these 11 design concept/idea/solution alternatives. Following are three recommended options of how the user can work with the generated design alternatives;

A. Continued sketching ideation activities, where the user uses these generated artifacts as visual stimuli. Any new inspiration gained from observing and analyzing these artifacts is to be sketched onto paper for continued design exploration.

B. Continue generating additional 3D models based on either any initially drawn sketch from step 1 or newly drawn sketches as performed in option A.

C. Continue generating new 3D models based on one or several of the generated 3D model design artifacts for further design exploration.

As inferred by the options themselves, what these designerly activities are aimed at eliciting; are to help with the iteration and exploration of one's own design concepts. These generated artifacts are to serve as an unexplored selection of the overall design space; giving the user who generates these artifacts insight into what has yet to be considered. Here the user is intended to be estranged [5,21] to their own design concepts. Through these new artifacts, the designer of the base artifact(s) is exposed to previously unexplored possibilities and angles of that concept as the shapes of these artifacts are altered iterations of that base concept. The designer can rediscover their own design concept, as what is generated is likely to highly differ from both the designer intent embedded within the base design [11] but also the direction the designer had in mind for that particular concept. The benefit of generative design as a source of inspiration for ideation in the conceptualization of new solutions (here concepts) is recognized by Caldas who explains in his article about generative design systems how these systems can help explore, compare and conceptualize different creative concepts [7].

Of note is that the options outlined above are intended not as a list where the user chooses one or the other, but as complementary to one another. Either A, B or C is chosen as a starting point and can be followed by the other options. The user can also repeat the same step multiple times. This process can and is encouraged to be repeated until the user has explored that concept to the point where they wish to move forward either by exploring other concepts or move on to the next stage of the design process.

For clarification, participants performing the study did however not have these specific options or steps as reference for how to conduct their ideation and concept exploration. The user study was performed with myself explaining and guiding participants through the technique. For this reason, they were not supplied with an outline of the steps or the options.

STUDY THROUGH DESIGN WORKSHOPS

A study was created and carried out to test how the developed prototype tool and the technique as a whole assisted ideation in practice. Of additional interest was feedback from participants in regard to their experiences using the technique and if they had any suggestions for improvement.

The study sessions were carried out on two occasions, the first was conducted with one student and the latter in a group with two students. The study sessions were set up as design workshops and will from this point forward be referred to as such. The participants were briefly informed that they were testing an ideation method. They were not informed that the study was looking at their ideation, as I believed telling them this could make them wary about their own ideation and the concepts they were generating, which could affect the results.

Both sessions started with participants being asked to generate design solutions for a design problem scenario composed specifically for the study and the design workshops. The design problem was one of product design, where participants present in each workshop session were asked to design a speaker that captured the feeling of sound in its shape. The target demographic for this product was described as young adults and the speaker itself was requested to be designed as aesthetically pleasing. Participants were not given much more information about the technique before their workshop session but were gradually introduced to the next activity as they performed and finished the one prior, in order to capture their genuine responses to each activity of the technique.

The study sessions were performed with design students at a university level. They all tested both the prototype tool and the steps of the techniques. University students were chosen as a target group as they are knowledgeable about a variety of design concept areas, are familiar with this type of problem-solving and ideation. Further, it was important to get feedback from individuals practicing design as the technique is directed at serving those practicing design work. The study would have lost validity if the target group had been one with no knowledge about creative design work.

RESULTS

During this section, the result and collected data of each design workshop are presented. The collected material from the completed workshop sessions includes; Participant designed artifacts in the form of paper sketches and 3D models. The 3D models, remade from sketches, were created in a co-creation like fashion, where I as the workshop conductor along with the participants remade their sketched concepts into 3D models. This was done as participants did not possess the skills necessary to 3D model their sketched concepts themselves. However, the 3D models were made accurately with each participant and according to their specifications in order to not lose the design intents of said participant [11]. The collected data also included observational notes of interesting actions performed by participants during each workshop session. Additionally, each session concluded with a brief interview, where the participants shared their experience of using the technique and were asked about the design exploration that had just taken place. These interviews are documented as audio files, transcriptions, and some additional comments.

Workshop session #1

The initial workshop session had one participant. They were given a quick briefing and introduced to the problem scenario. They were then asked to start ideating concept solutions to the problem scenario by sketching on paper as per step one of the technique. An initial time limit of 15 minutes was set for ideation during the first step. This time limit was deemed necessary to guide the participant and provide structure to the workflow. Simply stating "ideate until you run out of ideas" would have been a diffuse ask to make.

Almost all sketches drawn during step 1 embodied and took the shape of some creative metaphorical reading of the presented problem scenario (see Figure 1). A mix of concepts included the physical form of sound waves and music-related forms. Two drawn objects looked more ordinary, one of a more standard rectangular speaker box (see Figure 1) and one of a cylinder.

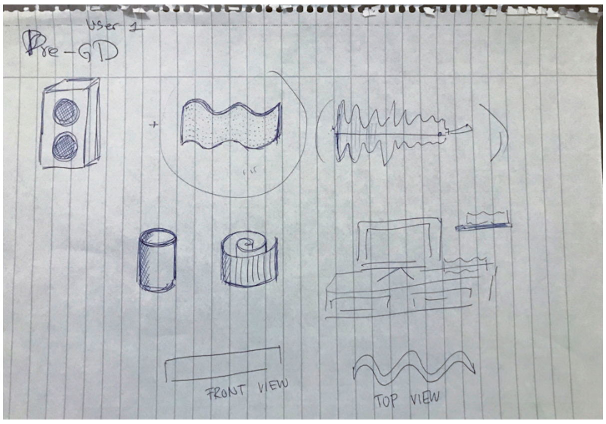

Figure 1: Sketches drawn during Step 1, from workshop session #1

Around 10 to 15 minutes in, ideation slowed down, and the participant was asked if they wished to continue ideating or move on to the next step. The participant decided to move forward to the next step of the technique. They were asked to single out one of the design concepts which had been ideated and sketched on paper to be recreated as a 3D model. In a collaboration between the participant and workshop conductor (me), the chosen concept was made into a 3D model. During this process, additional sketches of the design concept from the front, top, and the shape drawn in a simple home environment were drawn to better convey to the workshop conductor (me) the scale and exact shape (see Figure 1). After the 3D model was finished, step 3 was initialized and design artifacts were generated using the tool. Given the nature of the base input concept, the generated alternatives were rather abstract. Many shared characteristics but one was more differentiated in relation to the others (see Figure 2, far right).

Upon having navigated the 3D software space and explored the generated artifacts, the participant picked out a few which they thought were the most interesting (see Figure 2). They started ideating once more and drew new ideas on paper. The new shapes and concepts being drawn were quite different from their initial sketches (see Figure 3). Some took direct inspiration from the generated artifacts and closely resembled one or two of the generated shapes. Others could observably have been seen inspired differently. Instead of mimicking the shape of the generated artifacts, these were more experimental and abstract. These sketches were observingly inspired by the "style" of the generated alternatives rather than the actual form. Taking aspects like intersecting geometry by translating it into a flower shape (see Figure 3). But also, notions of the "abstract" and the "obscure" were observed as inspiration for the design concepts, resulting in futuristic sci-fi looking shapes (see Figure 3).

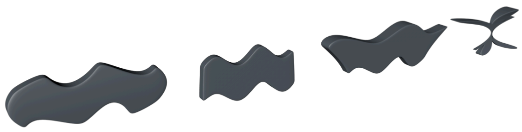

Figure 2: Interesting generated artifacts, selected by the participant from workshop #1

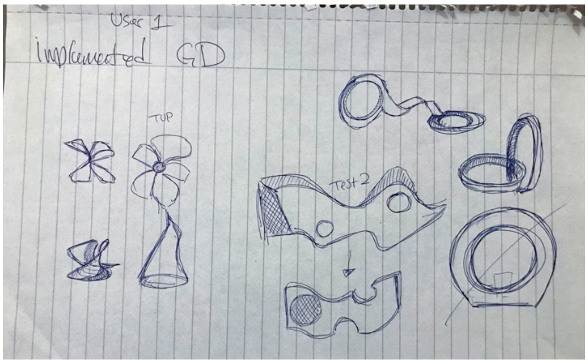

Figure 3: Sketches drawn during Step 3, from workshop session #1

During the post-workshop session interview, the participant commented that the experience has been fun and interesting. The participant described that different shapes (as observed) had inspired them with new ideas. Additionally, they were asked if they felt this technique had helped them ideate and they answered that it had. The participant also noted that they would consider using the tool for drawing in 2D, but also for abstract art. They said that it was like a great replacement for Pinterest and other visual stimuli. In other words, having this tool and workflow worked as a replacement of other sources of ideation, and was thus a catalyst for visual inspiration during ideation. When asked about any critiques or improvements that could be made to the tool, the participant noted that some generated alternatives looked very similar.

Workshop session #2

The second workshop session included the same design scenario and set up as the first workshop (including the same 15-minute time limit for step 1). This second workshop differed however as it contained two participants. They were both briefed and given the problem scenario simultaneously as to not have one or the other receive more time to think about possible solutions or influence the other participant. Of note is that this design workshop was not specifically set up as a collaborative one. They were not told to avoid collaboration but were asked to ideate and explore problem solutions individually.

One participant (P1) expressed to both the workshop conductor (me) and the other participant (P2) that he was not pleased with the concepts he was coming up with and was exploring. P1 explained that the design concepts were not as substantial as was hoped. This disappointment persisted throughout the session. On the contrary, P2 was happy with the design concepts being designed and explored. Of the two P2 was the most enthusiastic as he expressed enjoying the work during the session.

In contrast to workshop #1, the participants of this second session drew more industrial looking concepts. P1 drew more rectangular and cylindrical concepts (see Figure 4). The majority of concepts drawn by P2 were triangular and cylindrical, with a few more distinctive concepts (see Figure 5). This second workshop session also spent a long time sketching during step 1 and surpassed the 15-minute time limit. P1's concepts were quite high in fidelity, including shading, textures, button placement, and other small details. P2's sketches were a bit lower in fidelity but still included light shading in addition to button placements and small details.

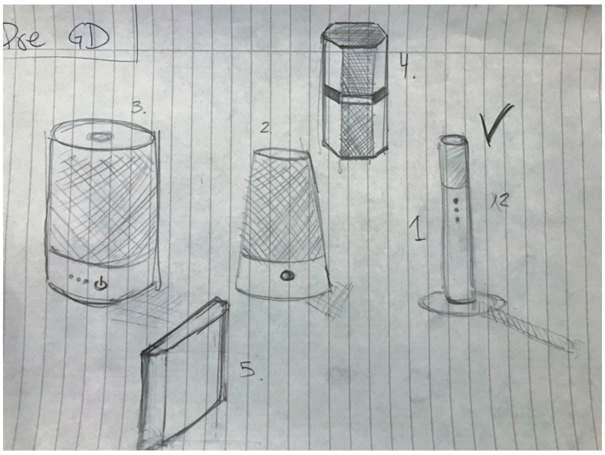

Figure 4: Sketches drawn by P1 during Step 1, from workshop session #2

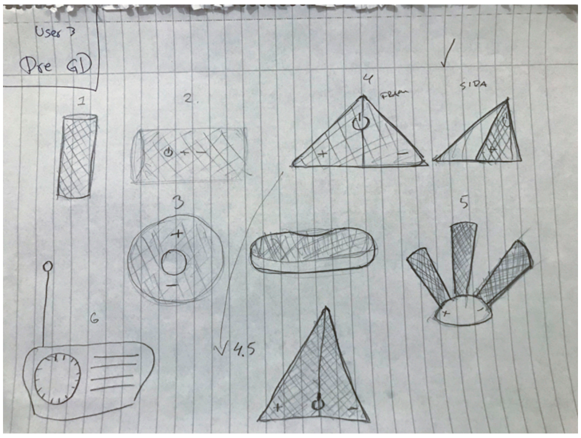

Figure 5: Sketches drawn by P2 during Step 1, from workshop session #2

Just like in workshop #1, participants were asked to select from their own ideated concepts, the one they believed to be their strongest and remake along with the workshop conductor (me) into a 3D model. Step 2 was initialized after they had made their selections, and the concepts were remade into 3D models. While P1 chose to generate one set of alternatives before moving forward (see Figure 6), P2 wanted to explore an additional cycle of generated artifacts after he had explored the first wave (see Figure 7) of artifacts. He was thus the single participant performing option C (of step 3) of the technique.

Figure 6: Generated artifacts, based on P1's design concept, from workshop #2

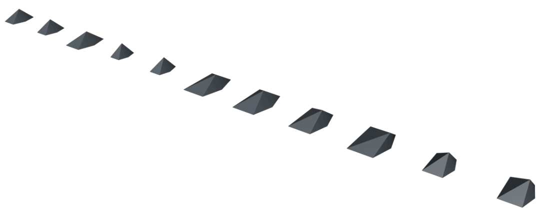

Figure 7: Generated artifacts, based on P2's design concept, from workshop #2

It should be noted once more that participants were not directly given options like A, B or C, but were rather asked how they would like to continue. It was important to provide a sense of freedom to the work, as the technique is about ideation and design exploration. It should thus elicit the freedom to explore how they see fit, which leads to an environment where creativity should thrive [1,2,12].

Following the exploration of the generated artifacts, both participants of workshop #2 stayed rather close to the generated artifacts they found appealing. During their second time ideating and sketching on paper, both participants explored solutions similar to those of their favorite generated artifacts, while simultaneously keeping the industrial aesthetic found in their initial sketches from step 1 (see Figure 8 & 9). P1 deviated most from these generated artifacts but still stayed true to the cylindrical form factor they ideated during step 1. P2 sketches show iterations of one or two concepts rather than a deviation.

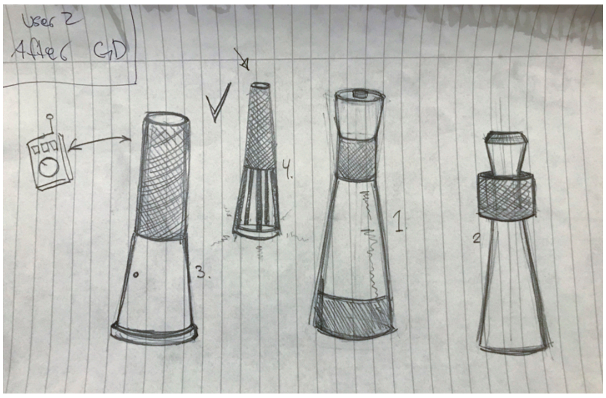

Figure 8: Sketches drawn by P1 during Step 3, from workshop session #2

Both participants used the generated artifact solutions more as a way of iterating on a few solidified base concepts, as opposed to looking for entirely new solutions. P1 did, however, explore new design solutions, albeit close to the other solutions in the design space.

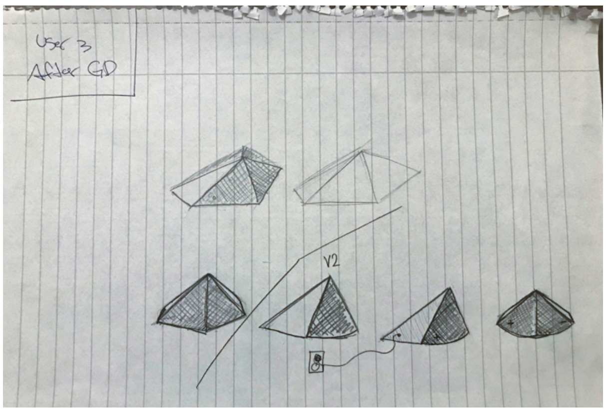

Figure 9: Sketches drawn by P2 during Step 3, from workshop session #2

During the post-session interviews, both P1 and P2 reported that the artifacts that were generated by the tool were similar to their base designs. Despite this, however, they both expressed that the artifacts provided them with new ideas, as can be visible when looking at the sketched concepts as ideated by both participants respectively during steps 1 and 2 (see Figure 4 & 5 and for comparison Figure 8 & 9). P2 explained that although the variation was not as wide as he in retrospect would have preferred– small increments of difference in the appearance of the artifacts made them either "neat or ugly". These incremental differences in appearance had a big impact on how P2 viewed and graded the concept variants. They influenced the design choices and inspired new ideas. This example shows that to a person who is not the designer of a concept, what can look like small iterations can, in reality, be of big concern for the designer. This thus proposes that exploring smaller differences in the generated design artifact solutions should not be disregarded and may be of equal importance as exploring bigger gaps in appearance.

Despite P1's unsatisfactory concept ideation, when asked how the experience was, P1 expressed that it was very interesting. P2 stated, "It was fun, super exciting exploring 3D solutions". P1 shared a kindred notion, expressing a want to further explore the solutions in 3D. Neither expressed much other criticism or critique when asked if there was anything they would have wished to see improved. They both did however like the idea of having more control over the way the generated artifacts are generated when presented with the suggestion. They liked the idea of having some sort of slider controlling how similar or dissimilar the artifacts would be. P2 also suggested being able to filter artifacts by height.

Post-workshop session thoughts

One concern present in both these workshop sessions was that, as no participants were well versed in 3D modeling, remaking sketches into 3D models would result in downtime where no ideation or design exploration could be done by the participants. The concern was that participants would feel like they had to wait for a 3D model of their design concept to be created. Which could have resulted in a slow workflow. However, this activity turned into a co-creation activity, as explained by participant P2 during the post-workshop session interview. He expressed that he did not share the worrying sentiment, but instead expressed that he saw the creation of the 3D model with the conductor of the workshop as a collaborative moment. This was to P2 an opportunity to further develop the idea as the 3D model was being created. Further, this co-design activity ensured that all participants got to explain, influence and confirm that their vision was realized and that their designerly intent [11] was not lost.

DISCUSSION

Computer suggestions as an extension of the self

One observation made while reflecting on the workshop sessions is how no participant questioned the process they were partaking in. To elaborate, participants embraced the generated design artifacts and how the prototype tool reinterpreted their design concepts. The psychology of ownership suggests that during the process of creating something, one of the most dominant forms of ownership is made [18]. Additionally, these types of attachment to created concepts can lead to one choosing not to collaborate as they do not wish to relinquish ownership of that creation [18]. Although this refers to collaboration with other people, I believe it to have relevance here in reference to the mixed-initiative [15] human-computer collaboration taking place with the prototype tool and the participants. The fear of technological automation overtaking human operations is a real concern for many [20]. Look no further than tablet screens replacing cashiers at your local fast-food restaurants. Creative fields are not beyond reach either, as a study speculates that photo editors have a high likelihood of their work being automated over the coming 20 years [20]. This fear of automating was however not present or mentioned by any participant in the study carried out in this paper. P2 of workshop #2 did during their post-workshop session interview explain that they thought they had the best solution in mind before using the tool. But when subjected to the generated artifacts harboring shape variations that opinion changed– making P2 open to re-explore that concept. Additionally, all participants told us they preferred their last iterated solutions as opposed to their initial ones. Letting other influences besides the creators themselves affect their design concepts did not seem to be an issue during the workshops where parts of the design process were automated by a computer. One possibility for why this might be the case could be that the participant did not view the prototype tool as an outside source or a replacement of them. Their own design concepts had defined and led the generation of the new artifacts. The tool could not perform its actions without the user input (as per design). Without the creative concepts generated by the human participant, the prototype tool would simply generate nothing. The prototype tool can then itself be seen as an extension of the participant's own self, where the generated concepts embody the design choices of the person inputting the base design.

The technique and creative motivation

Although the participants in the study agreed to test an ideation technique, there was no guarantee that they would enjoy or be motivated by it. Intrinsic motivation [1] drives successful creativity better than any external motivation like monetary compensation or a looming deadline. Here the external motivator was identified as the agreement to participate, therefore it was not their intrinsic choice to use the technique or attempt to solve the design problem. It was something they were told to do as the workshop sessions began. Despite this, all participants in the workshops did explain that participation in the workshop was interesting. Specifically, the participant of workshop #1 and P2 from workshop #2 expressed the work they performed during their workshop session as fun. The experiences as noted by these two participants show signs of intrinsic motivation occurring, specifically in terms of personal engagement and the enjoyment they described experiencing (as noted by their post-workshop sessions interviews). Additionally, P2 (of workshop #2), wanted to explore additional generations of generated design artifacts, exceeding the minimum requirements of the workshop session. These actions and decisions can also be read as signs of intrinsic motivation occurring, as the personal engagement to the process led P2 to perform more creative work than needed. This result of increased engagement can also be linked to the psychology of ownership [18], i.e. to the sense of possession people feel to their creative concepts as they are being created. Rouse explains that the creation of a concept forms one of the strongest forms of attachments [18]. This sense of possession could explain why P2 wanted to continue exploring the concepts to a greater extent, as P2 possesses such strong attachments to them, wanting to see just how far these concepts could be explored and iterated on.

The technique and creativity in the process

As visible throughout the documented study, the technique was successful as a facilitator of creativity as it assisted the creative process (which elicit creativity [1]). The technique assisted the participants in viewing the problem solutions from new perspectives. This occurred as the concepts participants had conceived to solve the scenario design problem were explored in new angles via the rediscovery of their concepts as it occurred through estrangement– embodied by the generated artifacts. In the same vein, it also helped the participants to break out of conventions and move beyond obvious solutions as evidenced by their first and final sketches (see Figure 1,2,4,5,8,9). Further, the concept ideated by the participant of workshop #1 (see Figure 3), where the concept is quite unconventional, one could read them as surprising– thus fulfilling an additional creation for creativity [3].

Rediscovering concepts

The ways in which the participant in workshop #1 took inspiration from the generated artifacts were quite different from that of the participants of workshop #2. The workshop #1 participant examined and drew inspiration as much from the shapes of the artifacts themselves as from connotations that could be observed. This manner of defamiliarizing [5,21] oneself with design concepts and re-reading and reinterpreting them through metaphorical and non-inferred meaning was an interesting development of how to mentally approach the ideation process, intentional or not. It is comparable to the approach to defamiliarization used by Blythe et al., where different lenses were used [5]. Different in this study is, however, the incorporation of both a "physical" (a digital representation, a deformity of the artifact) defamiliarization element in combination with a mental re-reading of the artifact. This combination turned out yielding interesting results, as the shapes present in the final sketches are, as previously explained quite stylized and I would argue, innovative (see Figure 3).

Variation in design alternatives

The variation in the generated 3D models differed. However, all generated design artifact cycles had a few similar results per generation; The tool did not overall generate extremely varied results. However, the base model and concepts present in workshop #1 were more unconventional, leading to more "radical" or novel results. In the case of workshop #2, generated designs were more similar, as noted by the participants. This did however not hinder ideation as evidenced by the resulting artifacts. By looking at the artifacts produced during workshop #2: from the initial conceptualized idea to the final iteration; one notices changes to the design, although it is not radically different.

The amount of “radicalness” or “randomness” present in the generated artifacts, seems to have been dependent on the appearance i.e. the shape of the 3D base design input. The variation present in the artifacts did however provide insight into what can facilitate ideation in the artifact differences, both small and big. Despite this, the variation present in the generated artifacts, and the results of how the prototype tool generates designs, is rated at fair or good, but not excellent, as the variation did not live up to the expectations and anticipations.

The successful ideation

Despite the averageness of the variation present in the generated artifacts– the overall results are promising. Looking at the designed artifacts and how every participant was able to iterate and evolve their ideated creative concepts is promising. By leaning on the concept of estrangement for participants to rediscover their concepts [5,21] and building on the concept of generative design as a catalyst for said estrangement; participants were able to explore new angles of their design concepts. Angles they had not considered or knew nothing about previously. The support of this technique leads to leaps in the design space from initial concepts to the final iterated versions of the concepts.

Unexpectedly, the similarity of some generated artifact was discovered to also be an asset, whereas the expectation was that greater changes in appearances present in the artifact would be the main contributor to exploring the design concepts. While this preconceived expectation was true for the participant of workshop #1, the smaller variations in appearances were influential to the participants of workshop #2. This does, however, align with the fact that in the first workshop, bigger shape variations appeared, and smaller appeared in workshop #2.

Nonetheless, both similar and non-similar generated artifacts were of use to the participants. As the second set of drawings made by each participant contains aspects or features that were entirely unexplored prior to step 3 of the technique. Using this technique is thus interpreted as a success. Participants were able to go beyond the scope of their initial design concepts to create more novel concepts. They were able to (as noted during interviews) improve and iterate on their design concepts, either through the discovery of entirely new concepts or refinements to existing ones.

This work is hardly the first to explore generators as aiding humans in creative tasks. Many mixed-initiative tools have been created for generating content in various contexts, see [15] for examples of mixed-initiative generator systems. Generative design systems also often concern themselves with generating the optimal content. See [7, 13] for such works. Where I believe my work carry novelty in this regard is how these artifacts are used. The generated artifacts are not automated as finalized production-ready pieces of content. As discussed above in the section titled “rediscovering concepts”, the artifacts are visual stimuli. The connotations, knowledge the user can draw, and the rediscovery of their concepts gained from these generated artifacts– are of more worth in this body of work than the actual artifacts themselves.

CONCLUSION

This paper has documented the creation and study of a technique consisting of sketching activities and a developed prototype tool rooted in generative design system frameworks. The technique has aimed to elicit ideation and design exploration during the ideate stage of the design process while designing physical tangibles. The effect this technique has in assisting ideation was tested through a user study. Following the research question posed near the beginning of this paper is answered.

The technique is appraised as being successful to elicit ideation per the design of the technique. The outcomes of the study were promising and the positive feedback from participants during the workshop sessions and in post-workshop interviews speak to this appraisal; the success of the tool as a mediator of ideation. Participants of the study expressed success in ideating and iterating on their creative concepts using the provided technique. The outcomes of the workshop sessions, i.e. the artifacts themselves point to how. The generated artifacts functioned as per intention as a source of creative inspiration, by estranging the user to their own concepts through artifacts– this despite the prototype tool generating artifacts that were to some extent similar in appearance and not as “radical” as desired. The generated artifacts served as visual stimuli and study participants used them to compare with their initial designs and drew inspiration in that manner to ideate further. Additionally, it was discovered that inspiration and ideation took place as a result of one participant exploring the connotations, metaphorical readings and interpretations of the artifacts which facilitated rediscovery. Furthermore, using the generated artifacts as starting points to explore entirely new angles and details of artifacts but also minor details in the case of very similar artifacts was discovered to be fruitful. Thusly, the proposed technique can through these preliminary findings be identified as a support for ideation through a myriad of estrangement activities, allowing for ideation exploration of before unconsidered and undiscovered aspects of design concepts.

As a final mention, I reiterate that all findings and results of this study can only be preliminary due to the small scale of participants included in the work.

Despite the preliminary nature of the results, I believe this technique has great potential in supporting the ideation stages of design work. I believe that it could be useful to HCI work as designers trying to solve problems through the creation of tangible design artifacts could, with this technique, explore additional variations to their initial concepts, providing them with more solutions to consider.

Future work

Future work could consist of expanding the scale of the study, to include more participants and also reach out to practitioners in addition to students. This could provide more consequential evidence for the effectiveness of this technique. An additional angle would be the inclusion of participants that are well versed in 3D modeling. This would allow for testing of the technique without the need for a conductor to remake participant sketched designs into 3D models. Furthermore, continue developing the prototype tool and upon its completion releasing it as a plugin practitioners and students could use in their actual work could be a future prospect.

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