# Idea Bits: A Tangible Design Tool to Aid Idea Generation for Tangible Manipulation

**Uddipana Baishya**
Simon Fraser University
Surrey, British Columbia, Canada
ubaishya@sfu.ca

**Alissa N. Antle**
Simon Fraser University
Surrey, British Columbia, Canada
aantle@sfu.ca

**Elgin-Skye McLaren**
Simon Fraser University
Surrey, British Columbia, Canada
emclaren@sfu.ca

## ABSTRACT

Tangible interaction design students often find it difficult to generate ideas for tangible manipulation. They often restrict their explorations to a few familiar possibilities. To our knowledge, there is no design tool that focuses on facilitating the exploration of a variety of manipulation and aiding generation of ideas for manipulation. To address this gap, we designed *Idea Bits*, a tangible design tool consisting of interactive physical artifacts that enable users to experience a set of manipulations. These artifacts are coupled with digital examples of tangible systems and technical implementation guidance to help users understand how to implement the manipulations. Our work contributes knowledge about the generation of ideas for manipulation and will be useful to tangible interaction design students, instructors, practitioners, and researchers.


*CHI'19 Extended Abstracts*, May 4-9, 2019, Glasgow, Scotland, UK.

ACM ISBN 978-1-4503-5971-9/19/05. https://doi.org/10.1145/3290607.3312820

**KEYWORDS**
Tangible user interfaces; tangible interaction design; manipulation; idea generation; design tools.

**CCS Classifiers**
Human-centered computing~Systems and tools for interaction design.

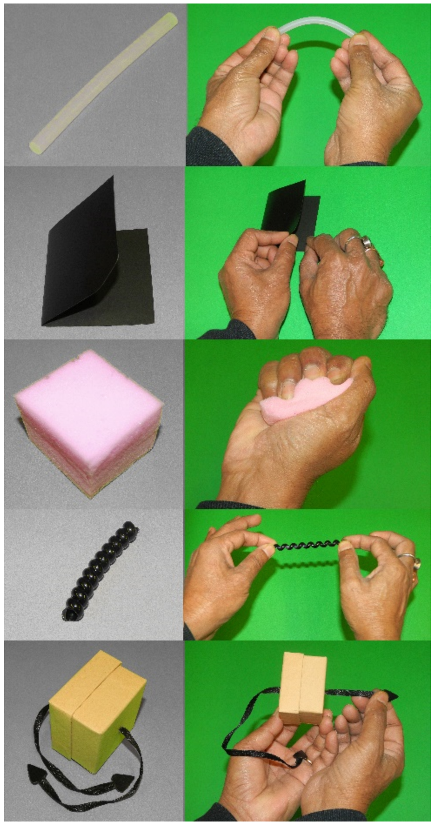

**Figure 1: Physical only set of artifacts (left) and the associated tangible manipulations (right) viz. bend, fold, squeeze, stretch and pull (top to bottom).**

## 1 INTRODUCTION

Input actions for tangible user interfaces (TUI) often involve the manipulation of artifacts through physical action. Students often find it difficult to generate ideas for these types of tangible manipulations [Alissa N. Antle, personal communication]. They often restrict their explorations to a few familiar possibilities. Broadening their exploration by considering a wide range of physical actions may help them to design manipulations that address their design problem adequately. Researchers have studied embodied ways of generating ideas [11] and bricolage in tangible interaction design (TIxD) [10]. Also, there are TUIs [6,9] to aid with certain aspects of TIxD. However, little has been done to support exploration of a variety of manipulations.

In this paper, we present *Idea Bits*, a tangible design tool to aid TIxD novices (called users henceforth) to generate ideas for tangible manipulation. Idea Bits consists of interactive physical artifacts coupled with examples of tangible systems and technical implementation guidance. Our research question is: *What are the key features of a design tool to aid TIxD novices to generate ideas for manipulation?* The contributions of our work are 1) knowledge about ideation for manipulations and 2) a tangible design tool to aid ideation for manipulations, which will be evaluated in future studies. This research will be useful to TIxD students, instructors, practitioners, and researchers.

## 2 BACKGROUND

### 2.1 Design Tools for TIxD

Several design tools exist to aid TIxD, but none to our knowledge focus on facilitating exploration of a variety of manipulations. Parkes et al. [6] developed a tangible system Bosu, to aid the design of transformation in actuated products. They found that working in the physical realm helped novices to understand the physical world while challenging assumptions related to kinetic behavior. The ability to experiment with a wide range of material and motion qualities inspired the creation of diverse solutions within motion design.

Sadler et al. [9] designed Bloctopus, a modular electronic prototyping toolkit that facilitated making circuits through direct electrical interfacing over USB. They found that the ability to swap different modules encouraged exploration of different forms of input interactions.

### 2.2 Role of Examples in Idea Generation

Idea generation usually involves inspiration, which is the process of evoking creative solutions with the help of an entity [4]. The use of examples can inspire ideas. However, research has shown both positive [3] and negative [3,5,7] impacts of examples on idea generation. The use of examples with desirable or innovative features may help overcome design fixation [5,7]. Cai et al. [3] studied the effect of five types of inspirational stimuli on idea generation for a house. They found a positive impact of text and sketch, while diagram, plan, and photo led to fixation based on the designer's experience level. Jansson et al. [5] studied design fixation caused by providing examples of flawed

**Figure 2: Sensor-enabled set of artifacts (left) and the associated tangible manipulations (right) viz. bend, fold, squeeze, stretch and pull (top to bottom).**

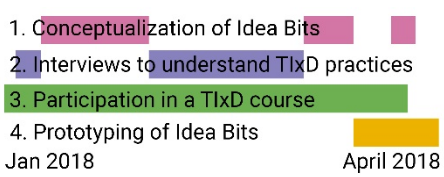


**Figure 3: Design research methodology timeline.**

design using diagrams with minimal text during idea generation for physical products by advanced undergraduate engineering design students and professional engineers. All participants showed design fixation. Purcell et al. [7] conducted a similar study and found that fixation occurred for advanced undergraduate students from mechanical engineering but not from industrial design.

## 3 DESIGN RESEARCH METHODOLOGY

We followed research through design [12] method, which is a method for interaction design research in HCI. Our methodology involved designing an artifact as a research instrument, rather than a commercially viable product, with the goal of producing knowledge. It involved an iterative process with four inter-related components (Fig. 3) 1) conceptualization of Idea Bits; 2) interviews to understand TIxD practices; 3) participation in a TIxD course; and 4) prototyping of Idea Bits.

The early phase of the process involved interviewing the second author, a tangible computing instructor, which helped identify that students often find it difficult to generating ideas for manipulation; further investigated later on. We then began *'conceptualization of Idea Bits'* which involved generating, selecting, detailing and modifying ideas for a research instrument to address this problem. To decide the manipulations we would support, we cataloged artifact mediated manipulations involving hands from a literature review of 62 papers on tangible systems taken from the proceedings of the CHI and TEI conferences. Of the 28 manipulations found, some were far more commonly used (e.g. translate, rotate) than others (e.g. stretch, pull)[2]. To our knowledge, no research states the later as inefficient manipulations. We questioned if they were instead less used due to non-obviousness. To open the design space of manipulations for users we chose five less used manipulations: bend, fold, stretch, squeeze, and pull, based on non-obviousness, but that had example videos, ease of technical implementation, possibility of variations and ease of user interaction.

From the very beginning of the process, the first, second and third authors *participated in a TIxD course* (IAT 882 Physical Computing, SFU, 2018 spring), as a student, the instructor, and the teaching assistant respectively. An early version of the concept for the research instrument involved two exploratory features - interactive physical artifacts and examples of tangible systems. At this point in time, the first author conducted one-on-one one-hour semi-structured *interviews* with her classmates from IAT 882. Without involving Idea Bits in these interviews, we investigated TIxD students' perception of *how they generate ideas for manipulation,* with a focus on *the challenges they face*. Because of the limited time available we used convenience sampling to recruit three male students (Bob, Mark, Sam), for whom the course was their first experience with TIxD. We did not discuss Idea Bits with the participants. The first author transcribed audio recordings of the interviews and analyzed looking for themes corresponding to the exploratory features of Idea Bits

[2] List of papers and manipulations can be found here https://goo.gl/BVeWLh

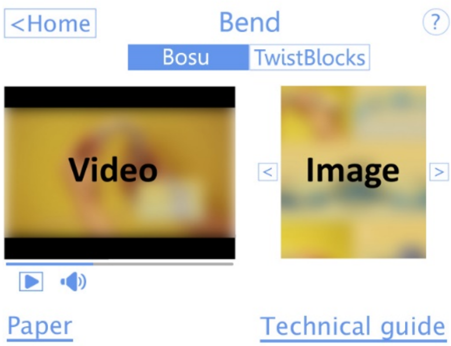


**Figure 4. Examples of tangible systems shown on a laptop.**

**Participants' Quotes**

1. "It [manipulation] is not something especially that I would think about through sketching. I don't really know how it [manipulation] feels like unless I actually touch it. I can't just pretend I am doing those movements." - Bob

2. "[To generate ideas] I just start walking and thinking. I have to be able to move my hands as freely as possible. I was thinking like I am the DJ [user]. I just imagine the artifact is there and I am working with it and you know gradually it shapes itself." – Mark

3. "I just didn't think about it [manipulations not seen in examples], like just coz it just never came to mind." - Bob

as discussed next. After analysis of the interview data, we *prototyped* Idea Bits. During this process, we added a third exploratory feature - technical implementation guidance.

## 4 DESIGN RATIONALE

Our current design of Idea Bits has three exploratory features 1) interactive physical artifacts that enable users to experience a set of tangible manipulations, 2) examples of tangible systems that incorporate the manipulations to help users understand how to implement them, and 3) technical implementation guidance to help users build their prototypes. We next describe how the various components of the design research methodology contributed to these features.

### 4.1 Interactive Physical Artifacts

There are two sets (physical only and sensor-enabled) of five artifacts (Fig. 1, 2). Each of the artifacts can be physically interacted with in one unique way (squeezing, stretching, bending, folding and pulling). By interacting with sensor-enabled artifacts, users can open the examples and play/pause the videos. We used a flex sensor, copper tape DIY switch, conductive rubber cord, pressure sensor and LDR to detect bend, fold, stretch, squeeze and pull respectively.

Our system enables users to physically experience manipulations by enacting different tangible input actions. Our interview analysis indicated that participants wanted to physically experience manipulations for generating ideas. For example, Bob and Mark found it difficult to generate ideas for manipulation through sketching as it did not let them enact the actual actions. Bob wanted to be able to carry out the manipulations for more accurate perception (see Quote 1 sidebar). Mark acted out the manipulations while imagining to be the user and the system to be in front of him (Quote 2).

We did a hands-on exploration of a variety of materials and objects for the artifacts. Each was designed to afford the manipulation it was linked with. We used generic artifacts to avoid possibilities of functional fixation seen with everyday objects (e.g. stress ball or hair elastic). Among the artifacts, we considered maintaining similar sizes, clear visual distinctions and the possibility of installing sensors. We considered usability factors such as freedom of movement for users, robustness, ease of expanding the set, implementation cost, and extent of physical-digital coupling. To prevent damage to the sensors from undesired interaction, we incorporated videos demonstrating how to interact.

### 4.2 Examples of Tangible Systems

For each manipulation, Idea Bits provides examples of two tangible systems using video, images, and a link to the published paper on a linked display (Fig. 4). For example, Bosu [6] is given as an example for bend. Examples are meant to help users understand how to incorporate the manipulations into their systems. The idea was inspired by TIxD courses that use examples of tangible systems to teach TIxD concepts. Studies have shown mixed results [3,5,7] for the impact of

**Participants' Quotes**

4. "I thought that maybe how can I use twisting. But frankly speaking, I had no idea how can I implement the twist in any [tangible] system. I had no example of such thing [tangible system] that [incorporates] twist." – Sam

5. "So I have seen a lot of systems that use this kind of connection [as a manipulation] right? So that's why it came easily in my mind." – Sam

6. "I have this sort of preconceived biases about like how people interact with devices. And in a way, I feel kind of restricted, and it'd be kind of cool to open up my mind a bit more to like these more broader kinds of interaction." – Bob

7. "I always prefer minimal kind of writing, not too much writing, that really makes me too much confused. There should be a image of that [example] so at a single sight, I can grasp the whole idea. And if there is a video then that's awesome." – Sam

8. "It [literature research] is something that I am sort of used to. I am not really sure of many other ways to do that [generate ideas] at least as this effective." - Bob

examples on idea generation, depending on the representation of the examples [3], the domain of study [7] and designer's experience level [3]. To our knowledge, researchers have not studied the effect of physical artifacts as examples, nor the effect of examples on idea generation by TIxD novices; hence we believe that use of examples with TUIs warrant further exploration. We found in our interviews that all the participants used examples. Bob and Sam found it difficult to conceptualize manipulations they did not come across in examples (Quote 3, 4). Participants felt negatively impacted by limited exposure to examples. Sam felt he considered only 'connecting' as the tangible manipulation for his system since it was involved in most of the examples he came across (Quote 5). Bob felt his ideas of manipulation were drawn upon input interactions of devices, such as smartphones, due to limited exposure to examples of tangible systems (Quote 6).

We provided two examples of tangible systems for each manipulation, to minimize possibilities of design fixation as compared to single example cases studied by previous researchers [3,5,7]. We considered video an important representational format to effectively depict the physical actions, along with providing images for quick reference and link to the published paper for reading about the system details. Sam found video and image easier and faster to understand, while he struggled with text (Quote 7). On the other hand, Bob generated ideas through literature research (Quote 8).

### 4.3 Technical Implementation Guidance

For each manipulation, Idea Bits provides technical implementation guidance by linking to Sparkfun [13] pages. This may reduce possible insecurities related to technical implementation. This idea was inspired while required to look over multiple websites to prototype Idea Bits.

A user begins by viewing videos in the GUI to understand how to interact with the artifacts. They are encouraged to pick up an artifact and interact with it. The GUI presents examples linked to the artifact automatically if the artifact is sensor-enabled otherwise the user can select it. They can then repeat this process using the other artifacts.

## 5 DISCUSSION AND FUTURE WORK

Based on an embodied view of design [2], we suggest that hands-on interaction may be beneficial for idea generation. TUIs facilitate body involvement through physical interaction and hence are worth exploring as design tools for idea generation. Facilitating exploration of design space and multiple alternative solutions is important in creative work [8]. Similar to Bosu [6], by letting users experiment with various manipulation, Idea Bits may support preliminary evaluation of diverse ideas at an early stage, especially for novice designers who often jump to implementation [1]. To support rapid prototyping and testing, the artifacts can be designed as plug and play prototyping modules similar to systems such as Bloctopus [9].

The results of the interviews may not be representative as they involved a limited number of only male graduate student participants. In the future, we will conduct more interviews and recruit female students to build upon our findings. We will incorporate computer vision in the physical only

**ACKNOWLEDGMENTS**

We would like to thank Dr. Thecla Schiphorst for her valuable guidance on planning, conducting and analyzing the user study.

set of artifacts to couple the artifacts with digital examples. We will make the sensor-enabled set wireless using XBee [14] to facilitate user movement by not having the artifacts wired with a laptop. We plan to expand the set of manipulations. We will conduct an expert review with four to six TIxD and usability experts to improvise the prototype. We will further evaluate Idea Bits with ten to twelve students having limited TIxD experience through case studies where they use it to generate ideas for tangible systems to address a provided design problem in a lab setting. We will video record the sessions and conduct interviews focusing on how they used the tool and if they found it helpful. This research contributes knowledge about challenges faced by TIxD novices in generating ideas for manipulation. It also contributes a yet to be evaluated design tool, Idea Bits, involving a novel integration of three exploratory features. Supporting the idea generation phase may result in tangible systems that adequately address the design problem at hand.

## REFERENCES

[1] Saeema Ahmed, Ken M Wallace, and Lucienne T Blessing. 2003. Understanding the differences between how novice and experienced designers approach design tasks. *Research in engineering design* 14, 1: 1–11. https://doi.org/10.1007/s00163-002-0023-z

[2] Alissa N Antle. 2017. Making Sense of Design Thinking. *She Ji: The Journal of Design, Economics, and Innovation* 3, 2: 92–96. https://doi.org/10.1016/j.sheji.2017.10.003

[3] Hui Cai, Ellen Yi-Luen Do, and Craig M. Zimring. 2010. Extended linkography and distance graph in design evaluation: an empirical study of the dual effects of inspiration sources in creative design. *Design Studies* 31, 2: 146–168. https://doi.org/10.1016/j.destud.2009.12.003

[4] Claudia M Eckert, Martin Stacey, and Christopher Earl. 2005. References to past designs. *Studying designers* 5, 2005: 3–21.

[5] David G. Jansson and Steven M. Smith. 1991. Design fixation. *Design Studies* 12, 1: 3–11. https://doi.org/10.1016/0142-694X(91)90003-F

[6] Amanda Parkes and Hiroshi Ishii. 2010. Bosu: a physical programmable design tool for transformability with soft mechanics. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems*, 189–198.

[7] A. Terry Purcell and John S. Gero. 1996. Design and other types of fixation. *Design Studies* 17, 4: 363–383.

[8] Mitchel Resnick, Brad Myers, Kumiyo Nakakoji, Ben Shneiderman, Randy Pausch, Ted Selker, and Mike Eisenberg. 2005. Design principles for tools to support creative thinking. In *NSF Workshop Report on Creativity Support Tools*, 25–36.

[9] Joel Sadler, Kevin Durfee, Lauren Shluzas, and Paulo Blikstein. 2015. Bloctopus: A novice modular sensor system for playful prototyping. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction*, 347–354. https://doi.org/10.1145/2677199.2680581

[10] Anna Vallgårda and Ylva Fernaeus. 2015. Interaction Design as a Bricolage Practice. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction - TEI '14*, 173–180. https://doi.org/10.1145/2677199.2680594

[11] Danielle Wilde, Anna Vallgårda, and Oscar Tomico. 2017. Embodied Design Ideation Methods: Analysing the Power of Estrangement. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17*, 5158–5170. https://doi.org/10.1145/3025453.3025873

[12] John Zimmerman, Jodi Forlizzi, and Shelley Evenson. 2007. Research through design as a method for interaction design research in HCI. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, 493–502.

[13] SparkFun Electronics. Retrieved July 17, 2018 from https://www.sparkfun.com/

[14] Exploring XBees and XCTU - learn.sparkfun.com. Retrieved February 16, 2019 from https://learn.sparkfun.com/tutorials/exploring-xbees-and-xctu/all