# Non-Visual Drawing Tool: Co-Designing a Cross-Sensory 3D Drawing Interface for and with Blind and Partially Sighted Drawers during Covid-19

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**Abstract:** Drawing as an activity aids problem solving, collaboration, and presentation in design, science, and engineering in addition to artistic creativity and expression in the arts. Blind and low vision learners still lack an inclusive and effective drawing tool, even in the digital age. Raised-line drawing kits aim to provide this, but blind participants found these to be barely comprehensible, most likely attributed to the fact that a line representing a surface edge reflects a visual bias that violates haptic principles of perception. In contrast, participants found 3D models to be more effective [2]. Thus, a drawing tool for the blind should afford 3D perceptual cues. How could this be afforded by a 3D drawing tool non-visually? Through, co-design sessions (conducted during the Covid-19 pandemic) with blind and partially sighted drawers (BPSD), I prototyped a 3D construction kit with a digital interface to translate 3D-haptic drawings of a custom-designed kit into an online virtual environment, suitable for 3D printing and collaboration.

**Keywords:** Blind and Partially Sighted Drawers, 3D Drawing Tool, Non-Visual Drawing

## 1 Introduction

**Topic:** This research aims to explore what an effective drawing tool for blind would be. It uses induction, co-design, and cross sensory design methodology to develop prototypes with two blind and partially sighted drawers through a longitudinal study.

**Research Gap (1): Perceiving drawings non-visually.** Raised line graphics are a common technique used to make graphics or drawings accessible for blind and partially sighted learners. However, for an individual who does not perceive drawings visually what does it mean to draw a line? If we consider an individual who has never been exposed to sight, their perception of the world in largely haptic. They would be creating mental models of the world around them through touch, for such an individual would an edge representing a line make sense? Most raised-line graphics in STEM (Science, Technology, Engineering, Math) textbooks follow visual cues of their source images,

such as perspective foreshortening, to convey depth, or textures to convey shadows, even though those lines are presented haptically [2]. Although some studies claim that raised line perspective views are useful with training others reported how low vision learners found these raised line graphic representations of objects difficult or impossible to comprehend, engendering recognition errors, more so when they lacked visual experience (even with training), in contrast 3D structures were more perceptible [3, 2]. Research in this area is still relatively new, this project aimed to approach the idea of "drawing" from a spatial perspective to allow creation of 3D structures as drawings or representations along with 2D raised line drawings.

**Research Gap (2): Current State of Drawing Tools for Blind.** Current analog tools such as raised-line drawing kits and swell paper [1], as well as digital devices such as TDraw [5] and grid-based drawing [4] reveal innovation in primarily 2D drawing techniques for blind and partially sighted learners. More recently, 2.5D tactile shape displays [7] and pin arrays show possibilities for three-dimensional (3D) design and creation for BPSI. At this time there continues to be a gap in the availability of a 3D drawing tool that will allow effective creation of mental models and thus ease of creation of drawings for blind.

**Approach so far.** Guided by participatory design, I used an iterative approach to codesign with two blind and partially sighted drawers. I used qualitative methods to ensure sighted bias was acknowledged and the lived experience of BPSD was amplified.

## 2 Work that has been completed

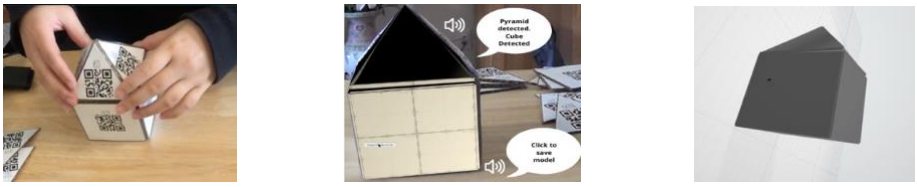


**Fig. 1.** Steps of Prototype 4: User creating a house using components of the non-visual drawing toolkit and creating a digital model using scanning application.

Through iterative prototyping with the participants, I came up with the concept of 3D construction kit that supports haptic principles of perception allowing ease of creation of mental models through bimanual 3D construction. It consists of 3D printed geometric shapes that can be connected to form larger structures. Other flexible components such as wax sticks and play doh were also included to allow for additional flexibility in

creations. An open-source digital scanning app was created that allows for scanning these geometric shapes through QR codes and simultaneous creation of a 3D digital model that can be shared virtually.

## 4 Going forwards

**Expected Contributions of Research.** The first part of this project provided information about components that are needed in a spatial drawing tool for blind and the importance of both structural and flexible components in creating 3D drawings. In the second phase of this project, I hope to develop this tool further and integrate it with an augmented reality (AR) based e-learning authoring platform. This tool aims to adapt elearning capabilities to facilitate 3D spatial information delivery in AR virtual learning content. This project provides students who are blind and partially sighted the opportunity to develop and design their own products to increase access in higher education design and engineering fields.

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