Idea11y: Enhancing Accessibility in Collaborative Ideation for Blind or Low Vision Screen Reader Users

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Abstract

Collaborative ideation tools like digital whiteboards are widely used by designers, academics, and creative practitioners; yet most ideation tools are inaccessible to blind or low vision (BLV) users. Informed by prior work on whiteboarding challenges encountered by BLV users and our formative study with eight sighted whiteboard users, we built Idea11y, a whiteboard plug-in that provides a hierarchical, editable text outline of board content, augmented with audio cues and voice coding. Findings from evaluation with thirteen BLV screen reader users revealed how Idea11y supported BLV users' understanding of clustering structure and streamlined their process to author, synthesize, and prioritize ideas on the board. Collaborative ideation sessions with six BLV-sighted dyads demonstrated how BLV users used Idea11y to develop collaboration awareness and coordinate actions with sighted collaborators. Drawing on this, we discuss ways to move beyond implicit visual norms in established ideation frameworks and practical considerations for future accessible ideation systems.

CCS Concepts

• **Human-centered computing** → **Empirical studies in accessibility**; **Empirical studies in collaborative and social computing**.

Keywords

Accessibility, blind, ability-diverse collaboration, creativity support, ideation, digital whiteboard

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1 Introduction

Collaborative ideation, i.e., generating, refining, and converging on ideas through group discussions, is a cornerstone of creative problem-solving in today's educational and professional settings [25, 85, 94, 110]. Although historically this process centered on physical whiteboards [68, 79], the rise of remote and hybrid work has made computer-mediated ideation [47] the new standard [48, 120]. Digital whiteboards have emerged as the primary medium for this transition, with tools like Miro [71] and FigJam [4] becoming integral to brainstorming in online classes [57, 69, 70, 93, 104, 106], design sprints [68, 81, 86], and user experience research [48, 84]. A 2024 survey indicates that over 74% of design professionals use digital whiteboards [120], exemplifying the widespread adoption of these tools in certain professions. Digital whiteboards enable visually organizing and iterating on concepts on boundless canvas spaces where users can collaboratively create, manipulate, and arrange digital content—from sticky notes to sketches and multimedia elements in real-time. The design of current digital whiteboards has come to fruition through over twenty years of HCI research on enhancing ways to explore, express, and expand ideas [47, 54, 55, 68]. Yet, this research has largely overlooked the needs of blind or low vision (BLV) individuals [36]. Consider the quote from one of our blind informants who was a disability inclusion consultant at a technology company.

> *"When we used Miro board for three days of design thinking, that was 100% inaccessible to me. It became so frustrating that I left. I had actually told them (collaborators)... but they carried on and did it [on whiteboard] anyway... I feel like Miro has missed that entire point of like, how do we make this both visually and non-visually helpful?"*

While a growing body of HCI research focuses on improving BLV users' access to collaboration technologies, e.g., document editors [40, 40, 77], slides [97, 98, 128], programming tools [96, 100], and computational notebooks [101], digital whiteboards include distinct interaction paradigms that require specialized accessibility solutions beyond standard web accessibility guidelines. Limited prior work has examined accessibility of ideation sessions for BLV people, but the work that does exist highlights their challenges while using digital whiteboards that rely heavily on freeform spatial arrangement, real-time visual feedback, mouse-based interactions (e.g., drag-and-drop), and the ability to quickly scan and process complex visual layouts [41, 46, 75, 116]. While sighted users can piece together scattered information on whiteboards by processing it in parallel or by rapidly glancing at persistent visual information, screen reader users must rely on speech or audio feedback and keyboard-based navigation that are primarily serialized and ephemeral [21, 39], which further limits their access to complex board content. In the absence of accessible ideation tools, BLV professionals must convince collaborators to relegate to traditional writing tools that are not preferred for ideation in predominantly sighted workplaces or remain entirely excluded from ideation sessions [41]. Thus, designing accessible ideation systems that preserve the creative and collaborative benefits of digital whiteboards while accommodating BLV users' access needs represents a critical gap in both accessibility research and collaborative technology design.

To address the gap, we design and implement new techniques to augment accessibility in digital whiteboards for BLV screen reader users and evaluate how these new techniques may shape their ideation processes with sighted collaborators. Through formative interviews with eight sighted whiteboard users, we identified their current whiteboarding practices and collaboration strategies that must also be accessible to BLV users to support effective ideation in ability-diverse teams. Combining these insights with prior work on accessibility challenges in digital whiteboards [41, 46, 75, 116], we developed four design goals to advance accessible whiteboarding systems. We instantiated these goals by building Idea11y, a whiteboard plugin that transforms freeform whiteboard content into a hierarchical, editable text outline linked to the whiteboard and updated in real-time. The system applies visual gestalt principles [124] to determine underlying content structure (e.g., sticky notes clustered by spatial proximity, color, or enclosure), presents this content in screen reader-compatible formats, and incorporates auditory feedback and quick navigation cues to facilitate collaboration awareness. We evaluated Idea11y through individual sessions with thirteen BLV screen reader users and collaborative ideation sessions with six BLV-sighted dyads. Results illustrated how Idea11y helped BLV users easily traverse, perceive, and author content on whiteboards and coordinate with sighted collaborators.

Overall, our work made three key contributions. First, drawing on our formative study and design goals, we built Idea11y[1] that introduces new techniques to analyze complex visuospatial information by algorithmically applying gestalt principles [10] on digital whiteboards and transforms board content into a hierarchical, cluster-based representation augmented with auditory feedback and navigation cues. With Idea11y, screen reader users are able to easily author and manipulate whiteboard content, such as creating, editing, reclustering, and removing sticky notes. Second, we present rich empirical understandings of how BLV users employed Idea11y to express, organize, and prioritize ideas and perform complex collaborative tasks alongside sighted collaborators. These insights extend prior work that built and evaluated accessible systems for collaborative writing [39, 77], programming [100, 105], and slides authoring [97, 128] by elucidating the unique complexities and tradeoffs related to whiteboarding. Finally, we revisit established creativity support theories and frameworks that prioritize visual modalities [22, 50, 51, 109] to foreground ways to foster accessible ideation in ability-diverse teams and outline design considerations for future ideation systems.

[1] https://github.com/NEU-TEA-Lab/Idea11y

2 Related Work

2.1 Theories and Frameworks of Creative Ideation

Over the years, researchers across multiple domains have developed theories and frameworks to conceptualize creative thinking and ideation. Guilford [59] divided the creative cognition process into divergent and convergent thinking, where individuals first come up with as many ideas as possible and then narrow these down to the most effective solution(s). Likewise, the Geneplore model proposes that creative activities include a generative phase to produce initial "preinventive" structures and an exploratory phase to interpret preinventive structures and build up final ideas [50, 51]. These preinventive structures could be entirely cognitive (e.g., mental models) or have physical representations, especially in visual forms (e.g., sticky notes, sketches) [35].

In the past two decades, HCI scholars have designed numerous creativity support tools (CSTs), where one of the main goals is to aid the ideation process; see [36, 54, 55] for an overview. Relatedly, Shneidermann [115] proposed a CST framework with four core design principles: support exploratory search, enable collaboration, provide rich history-keeping, and design with low thresholds, high ceilings, and wide walls. These design principles have been manifested in various ideation tools that enable multiple users to preserve, share, and expand ideas [73, 102]. To date, however, the theories and frameworks of creative ideation primarily centered on sighted people, ignoring ways to foster nonvisual approaches to collaborative ideation for BLV individuals.

2.2 Collaborative Ideation Tools and Practices

Traditionally for collaborative ideation, people have relied on physical tools that provide tangible, manipulable interfaces to organize thoughts. For example, physical whiteboards offer expansive surfaces for free-form expression and visual mapping of ideas, while sticky notes enable rapid idea capture with the flexibility to cluster and prioritize ideas through spatial rearrangement [35, 52]. The transition to digital ideation environments has been driven by technological advancement and practical necessities, especially following the rise of remote collaboration. Researchers have digitized physical whiteboards and sticky notes [68, 86], for example, to capture and reuse ideas on physical boards [27, 121]. Others developed new ideation platforms, including tabletop systems [37, 63], wall displays [114], virtual reality applications [26, 64, 79, 92], and AI assistants [34, 62, 102, 113, 117, 119]. Among these, digital whiteboards (e.g., Miro, FigJam, Mural, etc.) have gained significant popularity in educational and professional settings [48, 69, 81, 104, 120]. These tools have evolved beyond simple digitizations of physical whiteboards to incorporate sophisticated features like real-time synchronization, multimedia integration, template libraries, and GenAI-powered assistants [19, 74, 95, 127]. Advanced whiteboards now include visual stimuli (e.g., sketches, images) to gather inspirational materials, arrows/connectors to sort and express logic, and collaboration features (e.g., commenting, real-time cursor movement, emojis, and voting) to help collaborators evaluate and iterate on one another's ideas [35, 42, 99].

2.3 Accessibility of Digital Whiteboards

While the visual-heavy design of digital whiteboards has been beneficial to sighted users, recent studies revealed significant accessibility breakdowns on these tools, jeopardizing BLV users' participation in collaborative ideation [17, 41]. Whiteboarding tools, such as Google Jamboard [5], posed severe screen reader-compatibility issues like unlabeled elements, unannounced notifications, and confusing navigation [18, 75]. When the whiteboard content was structured as linked-node diagrams (e.g., mind maps), BLV users struggled to understand the spatial relationships between elements [46]. When the content was unstructured and messy, as sighted users frequently adopted during early phases of brainstorming, it was even more difficult to understand board content, forcing BLV users to abandon these tools and switch to document editors (e.g., Google Docs) [41].

Given these challenges, researchers explored new mechanisms to improve accessibility of digital whiteboards following accessibility and usability guidelines [111], such as introducing keyboard-based navigation schemes [6], AI-generated suggestions for alt-text [14, 116], and having a mediator to add live descriptions [53]. Others investigated multimodal techniques including audio cues with keyboard navigation to announce parent and child nodes in linked-node diagrams [46], tactile gestures on a tablet application augmented with musical tones and speech [129], and gesture-controlled whiteboards that allow content authoring using a webcam [56]. We extend these efforts to support real-time collaborative ideation for BLV screen reader users by identifying the underlying clustering structure on whiteboards and transforming this into a hierarchical, editable, and easily navigable outline to facilitate both content reading and co-authoring on the board.

2.4 Accessibility in Ability-Diverse Collaboration and Content Creation

While research on accessible ideation is nascent, a growing body of work investigates how people with diverse visual, hearing, physical, or cognitive abilities engage in collaborative activities together; see [126] for an overview. Drawing on Disability Studies literature, Bennett et al. [24] posited the interdependence framework that highlights how access is co-constructed through disabled people "*being and doing together*" with non-disabled collaborators, assistive technologies, and the environment. The ability-diverse collaboration framework categorizes the collaboration process into ability-sharing and ability-combining types, where technologies can transfer, augment, and merge team members' abilities for effective collaborative outcomes [126].

Closely related to our work are the studies investigating accessible collaboration and content creation for BLV users in various contexts, such as document editing [39, 40, 77], slides authoring [97, 98, 128], programming [49, 100], and gaming [58, 118]. For example, to make visual structures on slides accessible, Peng et al. [97] automatically extracted hierarchical levels (titles, dividers, topic splits, etc.) embedded in slides and arranged them into an screen reader-compatible format. To help BLV users develop collaboration awareness [60], researchers explored different auditory techniques, for example, combining speech and non-speech audio [88] to communicate collaborators' cursor proximity and edit frequency on a shared document [39, 40, 100] and spatial audio to indicate collaborators' locations on digital interfaces [77, 90] or around tabletop systems [87]. Building on this work, we developed an accessible whiteboarding system augmented with auditory cues, voice coding, and efficient keyboard navigation features to support ideation between BLV and sighted collaborators.

3 Formative Study

Prior work showed that access barriers in collaborative ideation is shaped by not only inaccessible whiteboard features but also how sighted people structure ideation workflows [41]. Therefore, we interviewed sighted professionals with significant whiteboarding experience to gain insights into their whiteboarding practices, collaboration strategies, and the visual components that they frequently use on whiteboards, which must be made accessible to BLV users.

3.1 Method

3.1.1 Participants. With approval from Northeastern University's Institutional Review Board, we recruited eight sighted professionals (6 female, 2 male; aged 22–34) through our research network and university-wide Slack groups. All participants regularly used whiteboarding tools e.g., Miro and FigJam. Table 7 in the Appendix presents participants' details.

3.1.2 Procedure. The first author conducted one-on-one, semi-structured interviews via Zoom in November 2024. After obtaining verbal consent, we requested participants to demonstrate their whiteboarding process using previous projects. P1 and P7 did not share their projects for confidentiality concerns and instead reproduced their whiteboarding procedure on an empty Miro board. We probed participants about the features they frequently used and their ideation strategies. We then conducted a brief ideation activity with participants on Miro using the prompt: "Develop strategies to make the passenger experience on public transit more enjoyable," drawn from prior work [65, 102]. To capture both divergent and convergent thinking processes [59], we asked participants to 1) brainstorm as many ideas as possible, and 2) select two most effective ideas. We asked participants to lead the activity by dictating what board elements should be used and facilitating discussion. Lastly, we concluded with a debrief interview, probing participants for clarification around salient interactions during ideation, e.g., their rationales behind using certain whiteboard elements. Each session lasted approximately 40 minutes. Participants received 20 USD Amazon gift cards each. All sessions were recorded and transcribed.

3.1.3 Data Analysis. We followed reflexive thematic analysis [28] to analyze the transcripts and video recordings. The first author open-coded transcripts using Condens [1]. We thoroughly examined whiteboard examples shared by participants and produced to uncover latent whiteboarding practices. The quotes and codes were aggregated on a whiteboard to generate initial themes via affinity diagramming [84]. Coauthors met regularly to review data and develop the final themes.

3.2 Findings

We identified four main whiteboarding strategies sighted professionals adopted during collaborative ideation.

3.2.1 Externalizing ideas using sticky notes and related visual features. Our analysis revealed the whiteboard elements and visual cues that professionals used to express ideas. All participants except one chose sticky notes because they were easy and efficient to use and reposition, which corroborates that sticky notes are the most utilized design material [23, 68]. P4 said, *"We drop in reference diagrams and images and then we recreate components (sticky notes) from those diagrams, so we can move stuff around."* Participants adjusted visual attributes of sticky notes (e.g., color) to amplify aesthetics and communicate *"additional layers of meanings"* (P1), such as idea categories or topics. Participants also associated note colors to their established meanings, such as red and green for negative and positive connotations. Other visual enhancements included bold-facing text or increasing a note's size to convey the salience of ideas, since these visual cues can increase prominence and easily draw sighted users' attention [30]. As P2 demonstrated: *"This is a major issue, so it's gonna be really big (increases the note size)."*

3.2.2 Clustering ideas into spatially distributed and bounded regions. An important part of the ideation process involves grouping ideas into distinct categories or themes [68]. To this end, participants positioned board elements into spatially distributed and/or bounded regions, following visual gestalt principles of proximity (i.e., closely positioned notes belong to the same group) and enclosure (i.e., notes bounded by a shape belong to the same group) [10, 124]. We observed two clustering patterns among participants: starting with pre-defined clusters and forming clusters along the way. In the former strategy, prior to the activity, participants added Frames (i.e., built-in rectangular containers) or shapes to divide the board into separate regions dedicated to different topics or individual collaborators. The latter strategy involved participants first throwing ideas onto the board without any structures and then categorizing the ideas into specific themes, either after a fixed time or when ideas reached saturation.

Although whiteboarding tools recently incorporated AI-powered features that autogenerate clusters [3, 9], by color or thematic grouping of text, none of our participants reported using these features in their professional context. P2 and P6 raised concerns about accuracy of AI-generated clusters, while P6 highlighted the benefits of manual clustering to amplify critical thinking and enjoyment. Irrespective of the clustering strategy, participants emphasized that to ensure accessible whiteboarding, tools must allow BLV users *"to group the things together or make it clear what the groupings are"* (P5).

3.2.3 Evaluating ideas through shared feedback. The next step after categorization is evaluating ideas to select the best ones (i.e., convergent thinking) [59]. To indicate their preferred ideas, many participants used visual features (e.g., emojis), while P7 reordered sticky notes by putting the highly-rated ones at the top and less preferred ones at the bottom of a stack. Participants who explored Miro's built-in voting feature during our sessions found this feature confusing due to the extra setup steps compared to directly adding emojis. Participants also used the commenting feature to discuss the generated ideas with their collaborators and provide feedback, especially during asynchronous collaboration. Some participants left feedback on sticky notes, because they found notes to be easier to use and more noticeable than comments which revealed the text only after hovering cursor over it. In this case, participants changed the note's colors to signal their role as comments and convey the urgency of feedback.

3.2.4 Tracking activity traces to develop collaboration awareness. To achieve effective collaboration, participants monitored who is doing what and where [38, 60] on the whiteboard using visual features such as real-time cursor movement. P2 explained, "*If the cursor just stands still and there's nothing going on, then I think they probably are inactive*." Participants also relied on the 'following' feature that jumps to the collaborator's location and verbal communication (if co-located or on a synchronous call) to achieve joint attention. For example, P6 redirected his collaborator's attention by saying *"Can you see my cursor? It is at the top green one."* This request employed three visual cues: P6's cursor location, the note's location (at the top), and its color (green). Participants also appreciated having a space to work individually with focused attention and the option to readily navigate to a collaborator's location when needed. Additionally, some participants attached tags or appended creators' names to sticky notes to *"see who's done what and then... ask for feedback"* (P5).

Importantly, we found that which collaboration cues participants monitored depended on the phase of ideation. At first, when participants concentrated on adding ideas, they intentionally avoided reading collaborators' ideas or activities so those ideas would not *"influence my thoughts"* (P3). Moreover, they found collaborators' moving cursors to be *"distracting"* (P2) when *"we just need to focus on ourselves"* (P6). In that situation, participants only desired rough ideas about collaborators' location to establish peripheral awareness [20] but appreciated visible cursor movement and the 'following' feature during focused collaboration. These practices suggest the need to support BLV users in forming collaboration awareness by providing real-time, non-disruptive, and *nonvisual* cues about collaborators' activity traces.

4 Idea11y: Design and Development

Informed by our formative study and prior work on accessibility barriers in whiteboarding [41, 46, 75, 116], we derived four design goals to help BLV screen reader users ideate on digital whiteboards alongside sighted collaborators. To realize these design goals, we built Idea11y, a plugin that works in tandem with Miro, a widely-adopted whiteboarding tool [120]. Below we describe the design goals and how we operationalized those in Idea11y.

4.1 Design Goal 1: Provide a hierarchical representation of board content and clusters

Digital whiteboards allow freeform placement of elements within an infinite canvas, potentially because it encourages sighted people to quickly put down their transient thoughts without thinking much about organization or being constrained by a rigid structure [107]. While some whiteboarding tools allow keyboard navigation in a linear or grid layout [8, 11], our formative study revealed that sighted users rarely maintain such straightforward layout during ideation. Instead, they arrange board elements in complex layouts where the underlying structure lies in how sighted people instinctively interpret visual clusters, for example, following gestalt principles [10, 122] of spatial proximity, color similarity, and bounded region (Figure 1). Screen reader users, however, cannot comprehend this clustering structure due to the lack of feedback indicating implicit connections between the sticky notes, although visually it is apparent by the notes' proximity, color, or enclosure [41].

To address this challenge, Idea11y represents board content in a <u>hierarchical, text-based outline</u>. First, we decompose an entire whiteboard into three levels: Frame, Cluster, and Note by algorithmically applying gestalt principles to identify implicit cluster structures that are not systematically encoded in the board's metadata. Then, we transform this content into a header-subheader-bullet list format, following BLV users' conventional practice of organizing ideas on document editors [41]. This way, screen reader users can easily navigate to different clusters and notes (Figure 2c) using familiar keyboard shortcuts (e.g., 'H'/'Shift+H' in JAWS/NVDA to navigate by heading levels). This approach to algorithmically applying rule-based heuristics e.g., gestalt principles to determine cluster structures has not been explored in prior work on accessible whiteboarding [8, 116] or collaborative accessibility in other contexts [39, 77, 97, 100].

To facilitate understanding of a cluster theme, Idea11y provides a concise, <u>AI-generated summary</u> of all notes within each cluster. The summary is updated in real-time as users add/edit notes within that cluster. Idea11y also presents a <u>board overview</u>, describing the number of frames, clusters, and colors of sticky notes on the board (Figure 2b). Currently Idea11y presents content on sticky notes only, since it is the most frequently used element according to our formative study and prior work [68]. However, the features can be extended to other text-based element types like text boxes and shapes with text. Extending Idea11y to visual features e.g., image, animation, video etc. remains an open area for future iterations.

4.2 Design Goal 2: Enable seamless manipulation of board content

Currently, some whiteboarding tools support keyboard-based content authoring (e.g., adding, editing, and repositioning sticky notes). However, these actions at best require performing a series of complex steps or at worst are entirely inaccessible to BLV users. Consider adding a sticky note on Miro [14]: screen reader users must first use the shortcut to open Command Palette, type 'Sticky', select color, and then enter text. However, the user does not get immediate notification of *where* the new note has been placed [41]. Another challenge is moving a note, which sighted users can easily accomplish with mouse-based actions (e.g., drag-and-drop). Although screen reader users can move a note by repeatedly pressing arrow keys, with each press moving it by a minuscule amount, this process is extremely time-consuming, and yet the user may not fully know the note's updated position.

To address this challenge, Idea11y allows screen reader users to easily add, edit, delete, and move a sticky note and change its color within the text outline described in Section 4.1. The <u>add</u> button within each cluster (Figure 2c) opens an input field where users can directly type their ideas and hit 'Enter' to submit or press 'Escape' to cancel the action. Users can <u>specify color</u> by typing '/<color name>' in the text field (default color is yellow if unspecified). The <u>edit</u> operation can be triggered by pressing a shortcut on a specific note ('ctrl+alt+e' on Windows or 'cmd+e' on macOS), which will present an input field filled with the original text of the note that can be changed by the user. It also presents a drop-down

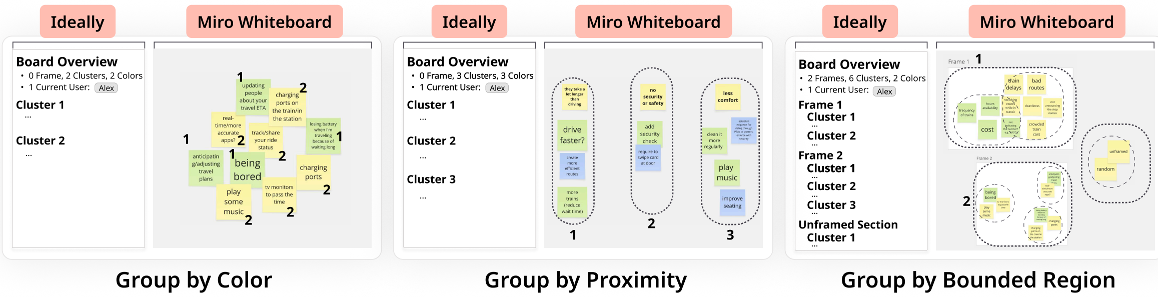


Figure 1: Three grouping mechanisms implemented in Idea11y based on visual gestalt principles. 1) If all sticky notes are crowded together, Idea11y will apply grouping by color. 2) If more than one spatially-distributed clusters are found, Idea11y will determine these clusters based on spatial proximity between notes. 3) If bounded regions (e.g., frames) exist, each frame and the space outside the frames will be considered as separate groups. Elements within each region will be further clustered by color or proximity. For example, notes within one frame or unframed region can be grouped by color but another frame can be grouped by proximity.

list of current clusters so the user can easily move the note to a new cluster (Figure 2d). Finally, Idea11y presents a Delete button to remove the note.

Idea11y enables a two-way manipulation between the whiteboard canvas and the text outline such that users can make changes on the outline and these operations are automatically reflected on the board and vice versa. For instance, if a user adds a new note in the outline, a new sticky note containing that text will be placed on the board within that cluster. Thus, Idea11y affords both sighted and BLV users reliable mechanisms to express ideas in their preferred formats (on a 2D canvas or a hierarchical text outline) and maintains consistent information across these two formats to support shared referencing during collaboration. This approach to support content authoring through a cluster-based, hierarchical, linked outline that enables two-way manipulation of content is a novel mechanism in the context of accessible whiteboarding.

4.3 Design Goal 3: Facilitate collaboration awareness through accessible navigation and auditory cues

As our formative study showed, sighted users make use of the visual collaboration cues on whiteboarding tools (e.g., 'following' a collaborator) to understand who did or is doing what and where within the board [39, 60]. However, screen reader users do not get any notification of their collaborators' activities, which hinders their participation in ideation.

Therefore, Idea11y presents various collaboration information when a screen reader user traverses and manipulates content in the outline. The board overview includes the number of collaborators and their names as interactive buttons (Figure 3a). Users can click to hear the collaborator's real-time location, i.e., the frame, cluster, and note where they are currently working on. Additionally, they can press a jumping shortcut (Figure 3b) from anywhere on the outline to redirect their screen reader focus to the note where a collaborator is currently at. The jumping shortcuts are chronologically mapped according to collaborators' joining time (e.g., 'ctrl+alt+1' for the first collaborator) and follow the same order as the name buttons in the board overview. Idea11y also gives spoken alerts (e.g., 'Alex has joined') when a collaborator joins or leaves the board.

During synchronous collaboration, an important challenge is preventing concurrent edits so collaborators do not unintentionally nullify others' edits [39]. To indicate collaborators' co-presence on the same note, Idea11y plays an earcon (beep) when the screen reader user arrives at a note where another collaborator is working (Figure 3c). Although we added earcons to minimize disruption in the user's workflow [39], they can choose to hear a spoken alert for co-presence along with or instead of earcons by adjusting settings (Figure 2a). We acknowledge that currently Idea11y does not visually render screen reader focus, which limits sighted collaborator's awareness of BLV users' location. Sighted users in our study devised a workaround by monitoring BLV users' screen reader focus leveraging the screen and system audio sharing features on Zoom. However, directly simulating BLV users' screen reader focus on the whiteboard canvas is an important next step, and we further reflect on this limitation in Section 6.2.2.

To understand who added what on the board, users can press a keyboard shortcut while their screen reader focus is on a particular note ('ctrl+alt+i' on Windows or 'cmd+i' on macOS) and hear a message about the note's creator and color (Figure 2e). This aligns with sighted participants' practice of attaching tags, appending creator names to note text, or color-coding notes to denote authorship. Moreover, Idea11y incorporates voice coding (i.e., reading out notes created by different users or having different colors in distinct synthesized voices) to help screen reader users process multiple pieces of information in parallel i.e., note text in tandem with its creator/color, given this technique was reported to be helpful to process collaborators' edits efficiently [40]. Users can configure the

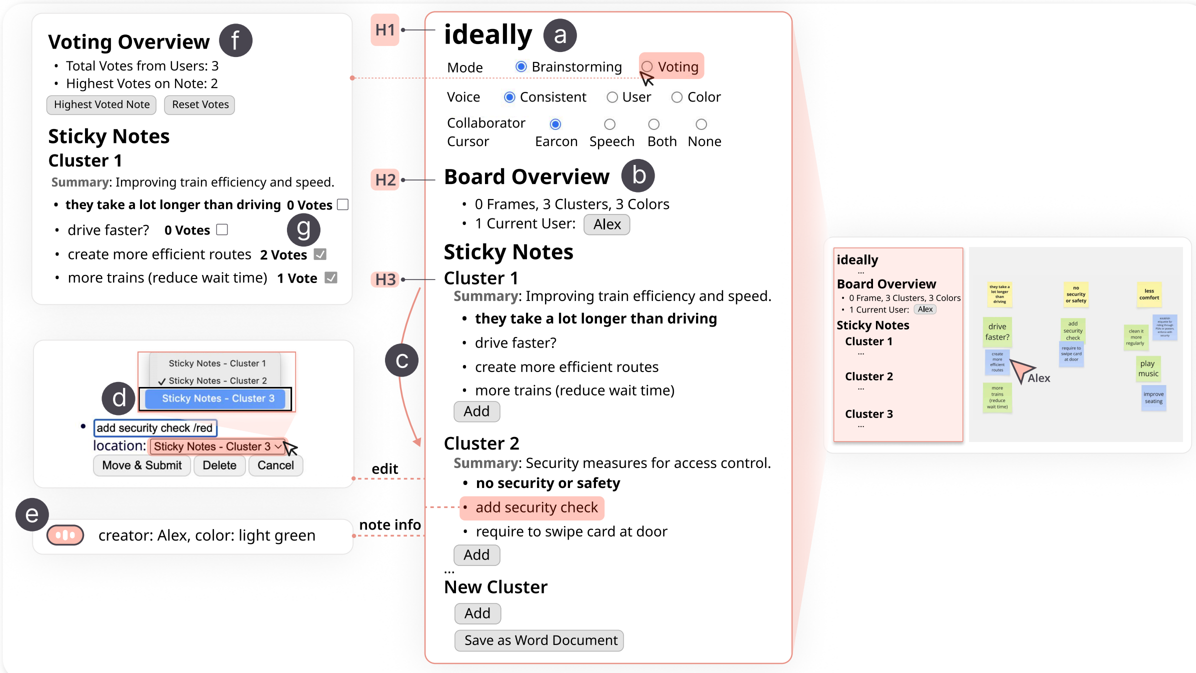


Figure 2: Idea11y represents whiteboard content in a hierarchical, editable text outline. (a) In the settings section, users can select the mode (brainstorming or voting), whether the content will be read in a consistent voice or in distinct voices for different creators or color, and whether collaborators' cursor co-presence will be notified with earcons and/or speech. In the brainstorming mode, (b) the board overview shows the total number of frames, clusters, and colors of sticky notes, number of active collaborators and their names in interactive buttons. (c) All sticky notes are arranged under frames (if exists) and clusters, following a hierarchical header-subheader-bullet list format. Users can add new notes within each cluster or create new clusters. When the screen reader focus is on a note, users can use keyboard shortcuts to (d) edit, delete, or re-cluster the note or (e) request the note's creator and color information. In the voting mode, users can (f) get a voting overview describing the total number of votes and highest voted notes and (g) use a checkbox to vote/unvote each note.

settings to apply voice coding by creator or color (Figure 2a), although the default configuration applies a consistent voice.

4.4 Design Goal 4: Support accessible ways to prioritize and select ideas

Our formative study revealed that sighted participants adopt different techniques like adding emojis and using the built-in voting feature to express their preferences. However, none of these techniques for idea prioritization and selection are compatible with screen readers. To address this, Idea11y incorporates an accessible voting mechanism within the text outline. Once users are done with adding ideas in the Brainstorming (i.e., idea generation) mode, they can switch to the Voting mode in the settings (Figure 2a). The Voting mode has a similar structure as the Brainstorming mode, including a list of notes under frames and clusters. The main difference is that users can now vote/unvote ideas by clicking the checkbox beside each note and hear the total number of votes a note has (Figure 2g). The voting overview section (Figure 2f) provides information about the total number of votes added by all users and the highest number of votes a note has received. The 'Highest Voted Note' button announces the content of the note(s) most favored by collaborators. Users can also restart the voting session by pressing the reset button. Thus, Idea11y supports a comprehensive ideation workflow from idea generation to idea selection and introduces a novel, accessible voting mechanism.

4.5 Implementation Details

We implemented Idea11y using React and TypeScript and interfaced with Miro Web SDK [15] to extract whiteboard element attributes and metadata. The backend was developed in Python using Flask [12]. We deployed Idea11y on Vercel [2] and hosted the server using Heroku [16]. To identify clusters based on

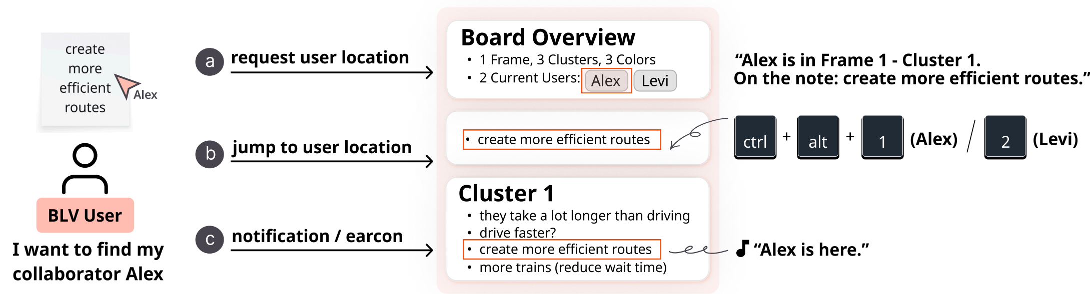


Figure 3: Idea11y conveys collaborators' real-time location in three ways. (a) Clicking the collaborator's name button in Board Overview announces the frame, cluster, and note content where the collaborator is. (b) Pressing the jumping shortcut at any time redirects screen reader focus to the note where the collaborator is. (c) When the screen reader user arrives at a note where the collaborator is (or vice versa), an alert is automatically played. This alert can be customized in the settings to be earcon, speech, both, or none.

spatial proximity, we applied DBSCAN algorithm [45] on the elements' coordinates. Other types of clustering was determined by directly analyzing element attributes (e.g., color and frames). For each cluster, we generated a text summary using a large language model API (gpt-4o-mini by OpenAI). To enable real-time synchronization of collaborative data, we used Firebase Realtime Database [7] to store user actions and locations. We used Web Speech API [13] text-to-speech service to assign voice profiles to collaborators, including four different English-speaking voices.

5 User Evaluation: Method

We conducted one-on-one evaluation sessions with thirteen BLV users and collaborative ideation sessions with six BLV-sighted dyads to investigate how ability-diverse teams may use Idea11y to brainstorm together.

5.1 Participants

We recruited 13 BLV participants (3 female, 10 male, aged 18–54) through our research network and snowball sampling. Participants rated themselves as expert (n = 11) or intermediate (n = 2) screen reader users. All had collaborative ideation experience; however, most (n = 10) reported little to no familiarity with digital whiteboards. Seven reported some whiteboarding experience for work or class purposes, although those were limited to basic functionalities of reading board content created by others and adding sticky notes. For collaborative work, they primarily used writing tools like Google Docs and Microsoft Word (n = 12), presentation tools like Google Slides and Microsoft PowerPoint (n = 11), and spreadsheets like Google Sheets and Microsoft Excel (n = 11). They had experience collaborating with sighted people (n = 12) and people with visual (n = 8) and non-visual disabilities (n = 4).

Following this study, we invited BLV participants to attend a collaborative ideation session using Idea11y as part of a BLV-sighted dyad. Six participants (B1–B6) agreed to join the sessions. Among them, B4 and B6 participated with a known sighted collaborator (S4, S6), although these sighted collaborators had limited familiarity with whiteboarding. To gather complementary perspectives, we recruited four sighted participants with extensive whiteboarding experience (but little to no interaction with BLV people) to pair with B1, B2, B3, and B5. Tables 8 and 9 in the Appendix respectively present BLV and sighted participants' details.

5.2 Study 1: Individual evaluation sessions with BLV screen reader users

The first author conducted one-on-one sessions with BLV participants via Zoom between March–April 2025. We adopted a within-subjects design where participants completed the tasks using Idea11y and a baseline interface (Miro) on two similar test boards that varied only in content. Prior to the sessions, we emailed participants instructions for installing Miro and Idea11y. The sessions started with briefly familiarizing participants with the composition and purpose of digital whiteboards. We used the analogy of header-subheader-bullet list (e.g., board as a document, frame as a header, cluster as subheader, and sticky notes as bullet points), given that BLV people often use this format for brainstorming on writing tools [41]. Next, we guided participants to the test boards modified from a board in formative study. Each test board had 17 sticky notes in 3 different colors arranged in 1 frame and 4 spatially distributed clusters. The notes were created by two user profiles. We gave participants two common-knowledge brainstorming topics (one per each board): how to improve public transport or online news reading experience. The interface conditions and test boards were counterbalanced to control the order and learning effects.

For each task, we first explained how to complete it with screen readers and then asked participants to try independently. The researcher played the role of collaborators through two different profiles to invoke the collaborative features. To capture participants' authentic impressions, we asked them to share their perception of the feature before explaining the actual functionality. Participants performed tasks in four categories.

(1) *Reading content and collaboration information:* Participants were asked to read through all the sticky notes and cluster summaries. Next, they had to find specific notes (e.g., mentioning public transport safety), navigate to the note where a collaborator was working on, and get the color and creator information of a note.
(2) *Manipulating board content:* Participants performed a series of manipulation actions to the sticky notes: add a new note, edit the text and color of a note, delete a note, and move a note to a different location or cluster.
(3) *Understanding voice coding:* Participants read content by applying different voice settings.
(4) *Voting:* Participants were asked to switch to the Voting mode to examine all the ideas and and vote on their favorite ones.

After completing each task category, participants rated on their effectiveness on a 5-point Likert scale and provided open-ended feedback. We also asked participants to rank Idea11y and the baseline (Miro) and share their rationales. Some features in task categories 1, 3, and 4 were unavailable or inaccessible on Miro. Hence, participants performed them with Idea11y only. Table 10 in the Appendix includes the Likert statements and open-ended questions.

During the sessions, seven participants used JAWS screen reader, four used NVDA, and two used VoiceOver. Each session lasted 90–110 minutes. Participants received 45 USD each via Amazon gift cards or Venmo. Based on participants' feedback, we made updates to Idea11y, such as added keystrokes for jumping to collaborators, modified collaborator cursor settings, and allowed exporting the text outline as Word document.

5.3 Study 2: Collaborative ideation sessions with BLV-sighted dyads

We conducted ideation sessions with six BLV-sighted dyads between April–May 2025. BLV participants used Idea11y and sighted collaborators used Miro (except for voting). Each session began with a one-on-one refresher of Idea11y with BLV participants. After sighted participants joined, we conducted an ice-breaker activity where both participants shared their favorite food or drinks on a whiteboard to build rapport [112] and gain familiarity with system functionalities. When needed, we introduced inexperienced sighted participants to relevant Miro features.

Next, participants brainstormed on "how to make remote collaboration engaging." We chose this topic because all participants were likely familiar with remote work. We provided a starter board that contained five sticky notes: one light yellow note stating the brainstorming topic and four orange notes with example ideas. We gave participants three high-level tasks for three phases of ideation: add as many ideas as possible on sticky notes (idea generation), organize ideas into clusters (idea categorization), and select two ideas by voting (idea selection). To capture naturalistic interactions, we neither enforced the use of particular features nor required participants to memorize keystrokes. Instead, we offered reminders for keystrokes as needed. To encourage participants to freely express their thoughts, we mentioned that their idea quality would not be judged.

Finally, two researchers conducted a one-on-one, debrief interview with BLV and sighted participants in separate breakout rooms, where they collected participants' ratings of Idea11y (BLV) or Miro (sighted) on the Creativity Support Index [32]. We probed participants for their thoughts on using Idea11y (or Miro) for brainstorming and the tradeoffs for using Idea11y compared to other tools. Each session lasted 90–110 minutes. BLV participants received 45 USD each and sighted participants received 30 USD each (they joined later and stayed for only 60 minutes) via Amazon gift cards or Venmo.

5.4 Data Analysis

All sessions were recorded and transcribed for analysis. In both studies, BLV participants shared their screen and computer sound (for capturing screen reader utterances) via Zoom. Sighted participants in Study 2 muted the shared computer sound on their end to minimize distraction; they could still hear others talking.

Qualitative analysis: Following reflexive thematic analysis method [28], the first author open coded all transcripts on Condens [1], taking a combination of inductive and deductive coding approach. Our deductive codes were informed by prior work on supporting accessible collaboration awareness [39, 40, 77] and design of auditory cues [91], while our inductive codes captured the nuances of BLV users' whiteboarding experience (e.g., how they understood sticky notes' spatial positioning and implicit connection between notes).

To examine BLV-sighted dyads' interaction with the systems and with each other, we analyzed video recordings following multimodal interaction analysis [43]. For this, the first author repeatedly watched the videos alongside participants' screen reader utterances to identify salient interactions, for example, BLV participants editing notes to provide feedback, initiating joint attention using the jumping shortcut, and reordering notes by coordinating with sighted collaborators. We wrote down minute details of unique vignettes selected for deeper analysis. All coauthors met regularly to compare data and codes. Through an iterative process, codes were aggregated and refined into final themes that captured perceived benefits and tradeoffs of Idea11y features and how participants made use of Idea11y to perform collaborative ideation routines.

Quantitative analysis: To calculate whether there were significant differences between BLV participants' Likert-scale ratings of Idea11y and the baseline in Study 1, we performed non-parametric, Wilcoxon signed-rank test [125], given that our data was not normally distributed and the sample size was small. For statements where comparative analysis was not feasible (e.g., tasks that were entirely inaccessible on Miro and performed on Idea11y only), we report descriptive statistics of ratings (mean, SD). Due to technical difficulties, B9 could not complete some tasks in Study 1. For quantitative comparison, we replaced B9's data with B13's data who completed the tasks under the same condition. We kept B9's data for qualitative analysis.

6 User Evaluation: Findings

We first present BLV participants' opinions on the effectiveness of Idea11y features compared to the baseline, Miro (Section 6.1). Next, we discuss how they used Idea11y for collaborative ideation with sighted collaborators (Section 6.2).

6.1 Assessment of Idea11y features

Overall, 12 out of 13 participants preferred Idea11y over Miro for collaborative ideation, while B2 had no preference. Participants were excited about incorporating Idea11y in various professional contexts including online tutoring (B4), design (B2), and *"collaborating in general"* (B8). Below we present their reactions to Idea11y features and their perceived benefits and tradeoffs.

6.1.1 Hierarchical, cluster-based representation. Participants shared that they could read board content easily and efficiently using Idea11y's text-based outline. Specifically, Idea11y significantly enhanced their understanding of how sticky notes were grouped compared to the baseline ($Z = -2.55, p < 0.05$). They also felt it was easy to understand the overall board information, including the number of clusters, active users, and colors (mean = 4.38, SD = 0.87). Some participants thought that Idea11y's hierarchical, cluster-based representation helped them "*visualize*" and build a mental map of the board. B8 was especially excited about this: *"[Google] JamBoard, it's designed very visually, there's no speech feedback. This (Idea11y) was just super easy and everything was arranged so neatly. I could visualize the way that it was in my head."* Relatedly, participants appreciated Idea11y's use of conventional, header-based navigation techniques, which allowed them to use their familiar shortcuts to *"easily navigate through each of the categories"* (B5) and quickly find content. B1 added that Idea11y simulated a *"semantic interface"* with *"good page structure and headings"* which *"makes it easy and intuitive for a practiced screen reader like myself to use."*

Despite these benefits, participants felt that they could not figure out the spatial arrangement of notes within a cluster or on the board, since Idea11y presented the notes in a list format. B2 said, *"I'm still a spatial thinker and like to organize things through mental mapping... This (Idea11y) is very linear. So there isn't any spatial positioning information about where those clusters are and the size of them."* This raised concerns about coordinating with sighted collaborators who may refer to a note by its relative spatial position. B6 explained, "*When sighted people describe things... They'll just tell you, 'Go to the middle, it's in the middle row on the left.'*" This challenge persisted on Miro as well. Although screen reader users could navigate notes using arrow keys and understand a note's immediate horizontal or vertical neighbors [6], they did not get sufficient information to construct an overall mental map of a cluster or the board. B2 described, "*I can move in all the directions... but to have an overall layout, that's more spatial [information] that is still missing.*" Moreover, Miro's arrow key-based navigation did not provide information about clusters or distances between the notes, leading to a misconception among seven participants that the notes were organized in a grid layout.

Furthermore, Miro's navigation did not align with the logical reading order, whereby the arrow keys traversed to notes that were on the left/right/above/below relative to the previous note but conceptually unrelated and placed far apart. B7 expressed frustration: *"It's not laid out in any logical way that I can make out, especially from a linear perspective as a screen reader user."* In the absence of contextual information, it was also difficult to track visited notes. Participants ended up reading the same notes repeatedly or skipping notes. In contrast, Idea11y presented all notes arranged by frames and clusters, making it easier for participants to comprehend the relationship between ideas and minimizing their chances of unintentionally skipping or repeating notes.

6.1.2 Reading note content. Participants appreciated that Idea11y delivered note text in a concise and straightforward manner with low verbosity while leaving additional details about its creator and color upon request through keyboard shortcuts. B8 exclaimed, *"I like how no nonsense and just boom boom it is... It spoke nothing but the element and I just heard it right away."* In contrast, Miro announced extra information (e.g., color, keystrokes to enter or exit frames, etc.) while reading a note, which participants found cognitively overwhelming. B3 stated, "*It's got too much information that when you're trying to actually get to the content, it can be a little distracting. Like green sticky note or whatever. I don't always need that information.*" Thus, Idea11y's on-demand note details streamlined screen reader users' reading experience.

6.1.3 Cluster summary. Most participants could easily understand what each cluster was about from Idea11y's AI-generated cluster summary. They commented that the summary was *"fascinating"* (B6) and *"cool"* (B3). However, B7 was confused about the timing and purpose of the cluster summary that were auto-updated in real-time, since it mismatched with his regular brainstorming workflow where themes were pre-defined by collaborators, such as clusters of *"what worked"* and *"what didn't work"* (B7). This concern could be addressed by allowing users to customize each cluster's (user-generated or AI-generated) summary/theme and show, hide, or edit its content on demand.

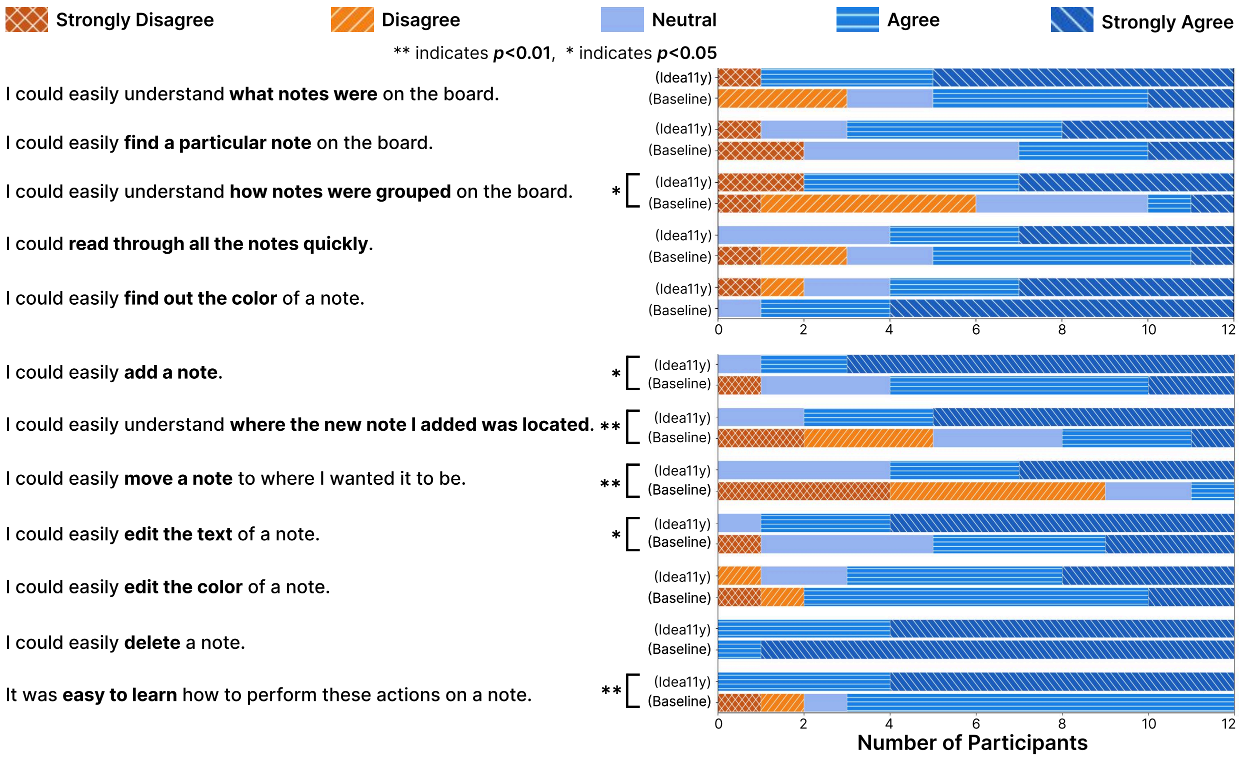


Figure 4: Distribution of BLV participants' (n=12) ratings for Idea11y and the baseline interface in Study 1 (from 1: Strongly Disagree to 5: Strongly Agree). Compared to the baseline, on Idea11y, participants found it significantly easier to understand how notes were grouped, understand where a newly added note was located, add, edit, or move a note, and learn to perform these manipulation actions on the notes.

6.1.4 Manipulation actions on the notes. Participants felt that compared to the baseline, they could easily add a note ($Z = -2.52, p < 0.05$), understand where the added note was located ($Z = -2.80, p < 0.01$), move a note to where they wanted ($Z = -2.93, p < 0.01$), and edit its text ($Z = -2.09, p < 0.05$) on Idea11y (Figure 4). Additionally, they found that performing these manipulation actions Idea11y was significantly easier to learn ($Z = -2.80, p < 0.01$).

Our video analysis provided deeper insights into the challenges that participants encountered on Miro and how Idea11y addressed them. On Miro, participants ended up creating multiple empty sticky notes, potentially because it required the user to press 'Escape' to submit a note after editing, or otherwise they remained stuck in the note's editing field. This caused frustration among participants who then triggered unintended actions (e.g., creating empty notes). Moreover, Miro neither provided options to specify the location of a new note nor confirmed where the note was placed. If the user was reading a note immediately before adding a new one, the new note would be placed on top of the previously visited note, which resulted in participants unknowingly creating overlapped notes.

Moving notes to a new location was even more confusing, since Miro did not provide meaningful screen reader feedback other than specifying the moving directions. B1 questioned, *"When I press left [key] one time, how much does it move it (the note)? Does it move it left by a column or something?"* B2 likewise pointed out the lack of details about the note's new surroundings: *"There's not a lot of feedback in terms of where I'm moving this auditorily... Like how far it's moved, if it overlaps another sticky note, or even if it doesn't overlap, where in relation the sticky note is now to the ones that are around it."* In the absence of such contextual information, BLV participants had to rely on confirmation from sighted collaborators (or researchers) whether or not a note was moved to their desired location. In contrast, they considered Idea11y's features for adding, editing, or moving notes easier, efficient, and more intuitive, as they could directly add/edit a note within a cluster or reposition a note by choosing its final destination from a dropdown list of clusters and immediately get a confirmation of the cluster in which a note was added or moved to.

Participants also suggested improvements to Idea11y's note editing process. Some were confused about the order of notes *within* a cluster in Idea11y's outline. This was because Idea11y ordered notes according to their coordinates on the board (e.g., the top note within a cluster would be the first in the list, the leftmost cluster will be cluster 1, etc.). Hence, a new note added by a BLV user could be positioned in the middle of the list, if its position on the board was in the middle of the cluster.

Table 1: BLV participants' (n=6) interactions with Idea11y features during the collaborative ideation sessions (Study 2). We list how many times a participant used the following features: add, edit, move, or vote on notes, request a note's information (creator and color), jump to a collaborator's location, and receive a push notification when running into a collaborator's cursor on the same note. 'Time' denotes the total time spent on the brainstorming task. Technical issues with screen reader focus jeopardized some interactions during B1's session (denoted by -). 'Get Note Info' was the least used feature across all sessions, potentially because BLV participants could identify the note creator by process of elimination (since there were only one creator except themselves), and showed little interest about note color.

Participant	Add Note	Edit Note	Move Note	Get Note Info	Vote	Jump to Collaborator	Cursor notification	Time (min)
B1	2	1	0	0	2	-	10	32
B2	9	0	4	0	2	4	4	28
B3	4	3	4	0	2	1	1	24
B4	7	0	1	2	7	0	0	25
B5	3	0	3	0	6	1	1	36
B6	6	0	0	0	6	6	9	41
Average	5.2	0.7	2	0.3	4.2	2.4	4.2	31

This mismatched with participants' expectation of the notes' ordering, where they expected the most recent note to appear at the end of the list. B4 stated, *"It didn't make sense [because] it wasn't an alphabetical or a timeline logical order."* Some participants desired flexibility in changing the order of the clusters or notes within each cluster. For example, B9 wanted to *"move [notes by] its priority, up or down."* This indicates that sorting sticky notes within a cluster chronologically by default while allowing users to reorder could make the board content more intuitive and easier to track.

6.1.5 Collaboration information. Overall, participants appreciated the ability to understand collaborators' real-time location and past activities on the whiteboard, which were inaccessible on Miro. B3 expressed enthusiasm about Idea11y: *"If this was available, I will start introducing it to my team tomorrow because we do a lot of collaborative things. And this is really very easy and functional and it gives me great understanding of what's going on when someone's presenting."* Specifically, participants felt that they could easily find out which note a collaborator was on (mean = 4, SD = 0.82) and who created what note (mean = 4.08, SD = 1.32). They appreciated getting on-demand collaborator information by pressing keystrokes, which did not interfere with their reading flow. B3 commented, *"That is very cool because... I can just read the notes and if I want to know who did it... It doesn't have to interrupt."* Participants also liked that they did not need to depend on transient notifications for important details about note creator/color or collaborator location. B5 stated, *"If you missed it, you could click it again and hear it."*

Participants felt that the real-time alerts for collaborators' co-presence on the same note made them aware of possible cursor collisions, which is necessary for multiple people to work in a shared workspace [39]. B8 explained, *"Any document platform where you're all on the same floor, you can collide with each other. It's hard to tell who's doing what and it's hard to tell where each thing is... [on Idea11y] I can do this without having to worry about cursors colliding."* However, participants expressed mixed opinions regarding whether push notifications about collaborators (e.g., joining/leaving the board or co-presence) disrupted their workflow (mean = 2.92, SD = 1.26). Six participants (B1, B2, B4, B5, B7, B9) reported that the notifications could be disturbing, especially when many collaborators worked together [39, 40]. B11 explained, *"While those [alerts] are really good, there are only two people in this board right now. I literally have boards at work that have maybe 8–9 people in it."*

6.1.6 Voice coding. Six participants (B2, B3, B5, B9, B10, B13) appreciated voice coding as an efficient way to convey creator and color information. B3 explained, *"Once I know what color that voice is, it's easier to just interpret the whole cluster as I go through, and it's one less thing to distract from the content."* Participants agreed that they could easily differentiate the voices for different creators (mean = 4.15, SD = 0.69) and colors (mean = 4, SD = 0.91) on the test board that had two creators (except the participant) and three colors. However, the number of collaborators or colors could affect the perceived ease of differentiating voices [40]. B6 described a scenario where memorizing voice profiles could be cognitively overwhelming: *"If we're in a meeting and we're talking about ideas and then I have to pay attention to which voice is reading which sticky note. I have to remember the voice associated with either the color or the user, plus the voice of the screen reader, plus the voice of the people in the meetings."* Additionally, B1, B9, and B10 felt that mapping voices to creators was more intuitive than colors, given the natural association between voices and human. B1 said, *"It wasn't automatically making sense why I was hearing different voices [for colors]."* Some participants wanted to customize the voice profiles depending on collaborators' gender (B6) or their individual audio processing preferences like speech rate (B9, B12).

6.1.7 Voting feature. Participants were generally satisfied with the voting feature and used it several times for voting on ideas during Study 2 (see Table 1). They felt it was easy to know which ideas were preferred (mean = 4.25, SD = 0.75) and express their own preferences (mean = 4.42, SD = 0.67).

Table 2: BLV and sighted participants' ratings of Idea11y and Miro respectively in Study 2 using the 10-point Creativity Support Index (CSI) scale [32] (ranging from 1: highly disagree to 10: highly agree). BLV participants rated higher mean scores for Idea11y on 'Expressiveness' and 'Immersion' compared to sighted participants' ratings for Miro on these two factors.

	BLV (Idea11y)		Sighted (Miro)	
Dimension	**Mean**	**SD**	**Mean**	**SD**
Collaboration	7.75	2.42	8.50	0.80
Enjoyment	7.58	1.93	8.67	1.07
Exploration	7.08	1.83	7.75	1.76
Expressiveness	**7.50**	2.11	**6.92**	1.56
Immersion	**5.58**	2.61	**5.33**	2.46
Results Worth Effort	6.83	2.29	8.17	1.27

They also found the voting overview about the total votes and highest voted notes useful (mean = 4.67, SD = 0.65). B11 stated, *"I think the most useful [feature] really is voting. I'm pretty impressed by it. Because I haven't seen a lot of interfaces do this super well, where you can really get a good sense of the votes that are currently there and you could check the ones that you want to vote yourself."* To improve the voting feature, B7 recommended sorting sticky notes across all clusters where the ones receiving higher votes would be placed at the top of the list.

6.2 Using Idea11y for collaborative ideation in BLV-sighted dyads

Our analysis of Study 2 data revealed how BLV participants used Idea11y alongside sighted collaborators to express ideas, track others' activities, provide feedback, initiate joint attention, and coordinate actions to synthesize ideas.

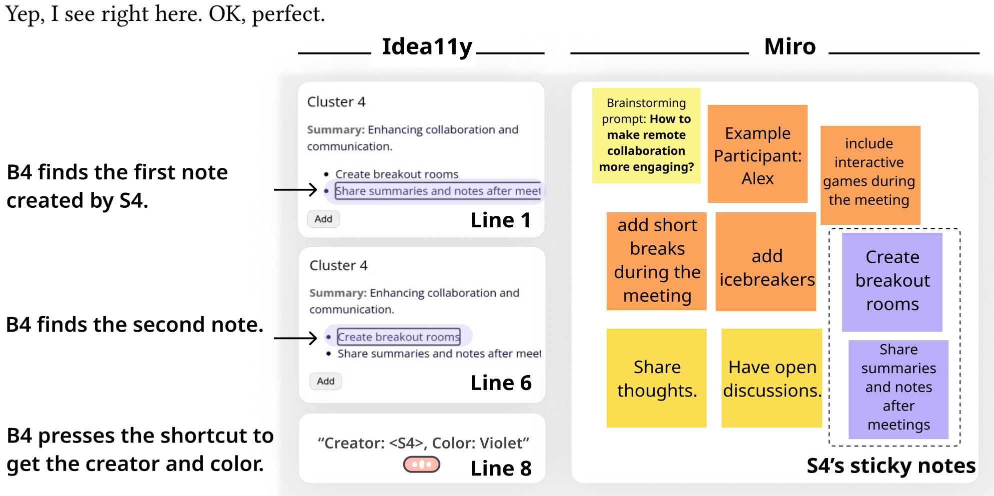
6.2.1 Expressing ideas by adding notes. Throughout the collaborative ideation sessions, BLV participants demonstrated active engagement in the idea generation process. Table 1 summarizes their interaction with Idea11y, which reveals that they added 5.2 sticky notes on average (lowest 2 by B1 and highest 9 by B2) to express ideas. Especially B2 and B4 added considerably higher number of ideas than their sighted peers (B2: 9 notes *versus* S2: 5 notes; B4: 7 notes *versus* S4: 3 notes). Participants' ratings on the CSI scale corroborate this observation (Table 2). BLV participants reported higher mean scores for Idea11y regarding 'Expressiveness' and 'Immersion' than sighted participants' mean scores for Miro on those two factors. While the populations evaluating the two interfaces are different and thus a direct comparison is not feasible, the CSI scores combined with our qualitative analysis allude that Idea11y may have helped BLV participants express their ideas by making the note creation process easier and get immersed in the ideation activity by reducing technological frictions. Moreover, BLV participants' mean scores for Idea11y regarding 'Collaboration' (7.75) and 'Enjoyment' (7.58) are moderately high, signaling that Idea11y may have supported them in performing collaborative tasks and made the whiteboarding process enjoyable for them. This is exemplified by B5's reflection on her ideation experience with Idea11y: *"It was really fun. It made me really use my brain and think... This was actually better the second time around (Study 2) because I was able to really engage more with it."* Although we did not ask sighted participants to interact with Idea11y, they commented on Idea11y's effectiveness. S1 said, *"I keep paying attention to Idea11y about different clusters ... I feel like it's helping organize the ideas better than the sticky notes [on Miro]... I felt a little bit jealous because he (B1) can edit it from Idea11y, but I can only edit from the sticky notes."* This comment hints at the broader applicability of Idea11y's hierarchical, text-based representation of idea clusters.

6.2.2 Monitoring collaborators' current and past activities. Our analysis revealed that BLV participants, especially B2 and B6, frequently used the jumping shortcut to monitor what and where their collaborators were working and to be "*on the right track*" with them (Table 1). B2 shared, *"I ended up relying on ctrl+alt+2 to jump to where they were a lot... Once I finished adding my notes. Just to see what they were doing periodically."* BLV participants also used the shortcut for pulling a note's creator information to review their collaborators' past activities. The vignette in Table 3 shows this interaction, where B4 is reading through all the notes to prepare for discussing ideas. In Line 1, he utilizes the shortcut to pull creator information and finds a note added by S4. He verbally checks with S4 how many notes S4 has added (Line 2). Upon learning from S4 that she has added two notes in total, B4 continues reading and arrives at a note that he assumes to be created by S4 (Line 6). He then presses the shortcut again to get confirmation on the note's creator (Line 7). Later, B4 reflected on this: *"I do like it (pulling creator information)... They did allow me to see which one hers were. I asked her how many she did because I thought she only had one. She said two, so I was able to use that [information] to find the other one."* This vignette also indicates that giving screen reader users an option to directly request the total number of notes added by individual collaborators could further streamline their ideation workflow, because otherwise they need to rely on verbal clarification from collaborators.

Our analysis also revealed a limitation of Idea11y which hampered sighted users' understanding of BLV collaborators' real-time activities. Although BLV users' note manipulation actions (e.g., add, edit, move, or delete) in the text outline were transformed to the Miro board in real-time, the movement of their screen reader focus was not visually rendered on the board. Hence, sighted participants found it difficult to track their BLV collaborator's location. During the session, S1 first muted B1's screen reader utterances (shared via Zoom) on her end but later unmuted it to follow *"where he (B1) is at and what he is hearing."* However, this workaround was not optimal, as collaborators' screen reader utterances became distracting to sighted users. Therefore, S1, S2, and S3 recommended visually showing BLV users' screen reader focus on the whiteboard canvas to *"mimic cursor interaction" (S3).*

Table 3: B4 finds out what ideas are added by his sighted collaborator, S4. SR: Screen reader speech.

1		*(B4 presses the shortcut to get creator and color information of a note.)*
2	B4:	Violet color, [I] see it. You only had one of them (notes), S4?
3	S4:	I had two [notes].
4	B4:	Two?
5		*(B4 continues reading to find another note created by S4.)*
6	B4:	Create breakout rooms (note text). Let me see. That's her.
7		*(B4 presses the shortcut to confirm the note's creator.)*
8	SR:	`Creator S4, Color Violet.`
9	B4:	Yep, I see right here. OK, perfect.

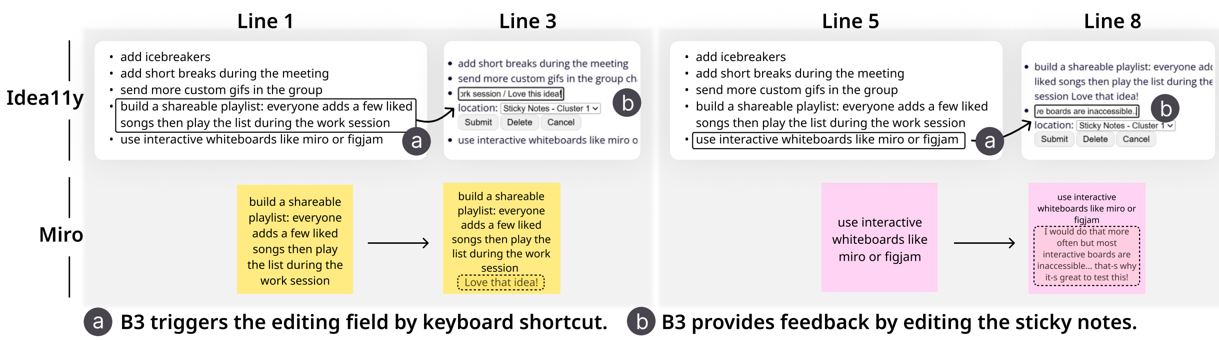


6.2.3 Providing feedback by editing notes. While we divided the ideation activity into different stages (generating, categorizing, and selecting ideas) to encourage divergent and convergent thinking [59], many participants engaged in these processes interchangeably starting from the early phases of ideation by reviewing their collaborator's ideas and sharing feedback. The vignettes involving B3 and S3 in Table 4 demonstrate this interaction. Here, B3 jumps to S3's location using the keyboard shortcut and reviews the notes S3 has added (Line 1). B3 then edits a note created by S3 to indicate her approval of the idea (Line 3), which S3 acknowledges by verbally thanking her (Line 4). Later, B3 edits another note created by S3 to expand on S3's suggestion to use whiteboards (Lines 6-8). In this example, B3 made use of Idea11y's note editing feature to exchange feedback, given the lack of a direct feature (e.g., commenting) to support this action. Interestingly, how B3 reappropriated the editing feature for a different task was not guided by the researcher or the sighted collaborator, illustrating that BLV users actively repurpose technological features to perform intended tasks that are not supported by default. B3 also wanted options to incorporate *"expressions, reactions, emojis... just to keep the conversation going without having to extra type things, but to know that you are engaged in that particular note."* This suggestion matches sighted people's use of emojis to convey preferences of ideas, as found in our formative study.

6.2.4 Maintaining joint attention. Our BLV and sighted participants adopted two primary approaches to direct each other's attention to a point of interest: using Idea11y's jump to collaborator shortcut and verbally referring to a cluster/frame. Table 5 illustrates an instance where B6 and S6 initiated joint attention by using the jumping shortcut. At first, B6 feels uncertain about where to add a new note, so she decides to put it closer to where S6 is working. As B6 articulates her intent (Line 1), S6 verbally describes her cursor location. However, S6's description is vague (*"where the prompt is"*; Line 2). When B6 tries to confirm whether it is in cluster 1 (Line 3), S6's response is still ambiguous (*"somewhere there"*; Line 4). At this point, B6 requests S6 to retain her cursor at a note (Line 6). S6 follows the request and verbally notifies B6 after selecting a note (Lines 7-8). B6 then jumps to S6's location by pressing the shortcut (Line 10). Upon jumping, B6 immediately hears the earcon, which provides her the confirmation that she has arrived at S6's location (Lines 11-12). This vignette illustrates that in the absence of clear verbal guidance from the sighted collaborator about their location, the jumping shortcut combined with the earcon provides a powerful mechanism to achieve common ground [60]. Later, B6 and S6 followed a similar workflow (select-then-jump) to initiate and maintain

Table 4: B3 uses the note editing feature to provide feedback to her sighted collaborator, S3. SR: Screen reader speech.

1		*(B3 jumps to S3's cursor location and reads a sticky note created by S3.)*
2	B3:	I love this.
3		*(B3 edits the note to append* `"Love this idea!"`*)*
4	S3:	Oh, thank you!
		...
5		*(B3 reads another note created by S3.)*
6	SR:	`Use interactive whiteboards like miro or figjam.`
7	B3:	I'm just gonna say that.
8		*(B3 edits the note to append* `"I would do that more often but most interactive boards are inaccessible...that-s why it-s great to test this!"`*)*



joint attention. In that instance, S6 wanted B6 to check her recent edits; so she moved her cursor to the edited note and asked B6 to jump to her location, saying: *"I'm going to select the sticky note and then find me."* B3 also mentioned that the jumping feature reduced her reliance on having sighted collaborators describe their real-time actions: *"It's hard to exactly know where they are or what they're referring to, especially if they forget to verbalize that. So it's very good to be able to track the speaker that's presenting."*

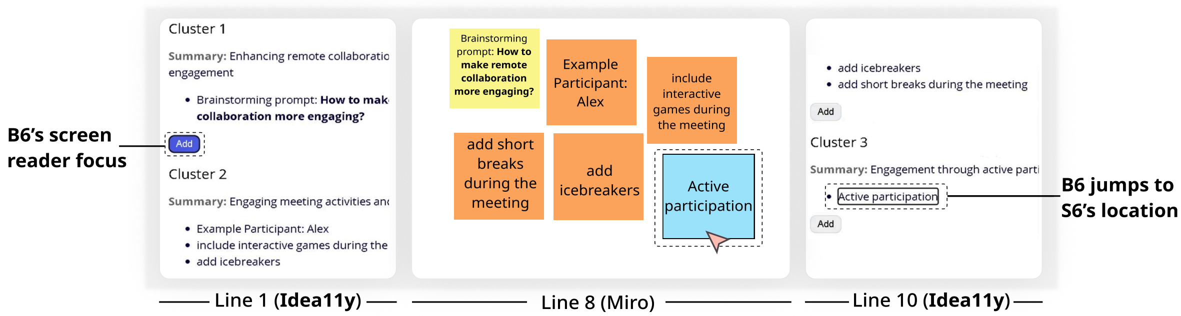
While Idea11y's jumping shortcut assisted BLV users in rapidly finding their sighted collaborators' locations, the reverse interaction was not as simple, since BLV users' movement of screen reader focus was not visible to sighted users on the Miro board (see Section 6.2.2). To address this, participants utilized Idea11y's hierarchical outline to formulate navigational signposting cues for directing each other to a shared location. In one scenario, while locating B1, S1 suggested that they both go to cluster 2. B1 followed S1's request and used the keyboard shortcuts for heading levels to quickly navigate to cluster 2 to join S1.

6.2.5 Coordinating actions to synthesize and reorder ideas. BLV and sighted participants closely coordinated their next steps to synthesize the ideas. Often they started by reviewing each other's notes, verbally discussed how they would like to categorize the ideas, and then rearranged the notes accordingly. While in existing whiteboarding platforms, BLV participants must rely on their sighted collaborators [41] to move sticky notes around—a particularly challenging interaction to perform with screen readers (see Section 6.1.4), we observed that both BLV and sighted participants in four sessions (2, 3, 4, and 5) simultaneously engaged in moving notes to different clusters (Table 1). Two important features in Idea11y supported this co-editing interaction. First, the feature to easily reposition a note from one cluster to another provided BLV participants the autonomy to make direct changes on the board. Second, the real-time notification for collaborators' co-presence on the same note alleviated the uncertainty of BLV participants unknowingly making concurrent edits with their collaborators. We also noticed that sighted participants in these sessions did not dominate the interactions (e.g., to finish the tasks quickly). Instead, both BLV and sighted collaborators negotiated who would perform what parts of grouping tasks. After completing their assigned tasks, sighted collaborators waited until the BLV participants finished reading and re-clustering their assigned notes.

Still, technical frictions occurred occasionally, requiring closely coordinated actions on each collaborator's part to handle these breakdowns. Table 6 shows one scenario where B2 adds a new note that stated the topic of all notes within a cluster. He verbally articulates his intent to place the topic note at the top of the bullet list in Idea11y's outline (Lines 1-2). However, since reordering notes within a list is not yet supported in Idea11y, S2 drags the topic note to the top of the cluster on Miro board (Lines 3), which is then automatically reflected and reformatted in Idea11y's outline. S2 also verbally confirms his action (Line 4). This create-then-reorder workflow happens each time B2 adds a topic note for other clusters (Lines 5-8). Thus, B2 and S2 successfully negotiated a

Table 5: B6 jumps to her sighted collaborator S6's location to initiate joint attention. SR: Screen reader feedback

1	B6:	Wait, where is <S6>? Let me go to <S6>. I'll just put it (the note) where she is.
2	S6:	Oh, I put the sticky note where the prompt is.
3	B6:	Oh, okay, so cluster 1.
4	S6:	Like somewhere there.
5	B6:	I see, let me find it really fast.
6	B6:	Can <S6> just keep your cursor there and then I can go to you?
7		*(S6 places her cursor on a note.)*
8	S6:	OK, I've selected my sticky note.
9	B6:	OK, let me go there then.
10		*(B6 presses the keyboard shortcut to jump to S6's location.)*
11	SR:	*(Plays earcon)* `List with one item 'Active participation'.`
12	B6:	It worked, okay.
13	S6:	Yeah, that's me.



closely-coupled routine to accomplish the task without one dominating the activity, even though Idea11y only partially supported B2's desired action.

Conversely, we noticed two dyads (B1-S1, B6-S6) adopting a stratified-division approach [83], where the BLV participant verbally shared how they would like to reorganize the notes while the sighted participant performed the actual moving actions on the board [83]. This happened potentially due to some technical issues. B1's screen reader focus frequently got redirected to unintended locations, making it difficult for him to directly move notes. In B6's case, she opted to read note content on her braille display instead of listening to the screen reader's auditory output. Therefore, it took her relatively longer to review all the notes, and meanwhile S6 finished reorganizing the notes according to their verbal discussion.

7 Discussion

Drawing from our findings, we interrogate visual-centric assumptions embedded in established ideation theories and technologies and reimagine more accessible alternatives.

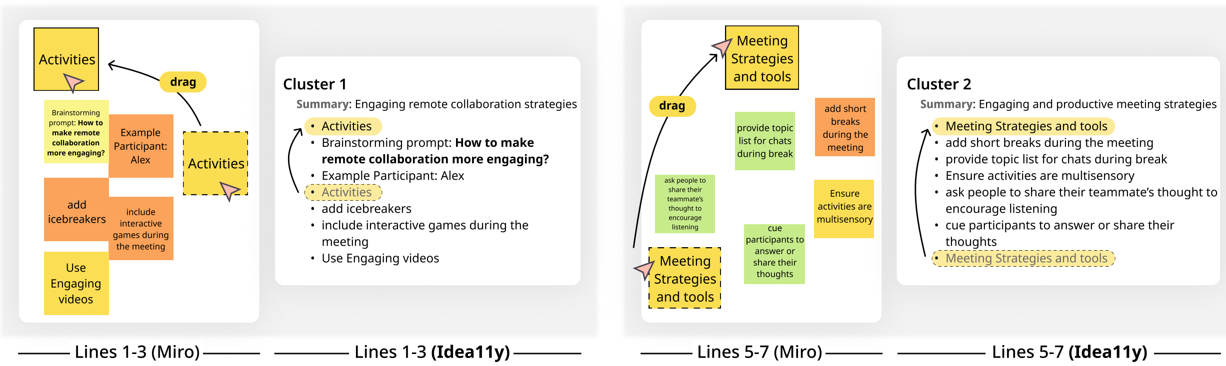
7.1 Reconceptualizing Visual-Centric Design Principles in Creative Ideation

Advancing accessible collaborative ideation requires critically examining how foundational theories of creativity support tools implicitly privilege visual modalities. Established frameworks like the Geneplore model [50, 51] position "visual patterns and object forms" as the most fundamental "preinventive structures" that spark creative thinking [29, 50], while Shneiderman [115]'s design principles emphasize visual strategies such as sketching, concept mapping, and information visualization as pathways to exploratory search and reaching the "Aha!" moment of creative breakthroughs. These theoretical foundations have directly informed the design of modern digital whiteboards, where sticky notes serve as visual representations of preinventive structures [22, 67], images provide inspirational reference materials [73, 74], and sketches help expand and refine concepts [33, 82].

This visual-centric paradigm, although beneficial to sighted users, excludes BLV individuals from collaborative ideation, potentially eliminating their roles as designers, makers, and creative practitioners [41, 61]. Our work reveals how whiteboards embed numerous *implicit* visual norms that help sighted users instinctively interpret information but are completely inaccessible to BLV users. These include, for example, visual attributes of elements (e.g., color, size, shape) that are adjusted to differentiate and convey salience of ideas, spatial arrangement that denotes how ideas are related (e.g., clustering by theme), and dynamic features that help establish collaboration awareness (e.g., real-time cursor movement). Critically, while individual board elements (e.g., sticky notes) may be technically readable by screen readers, the relational and structural

Table 6: B2 and S2 coordinate with each other to reorder notes within a cluster.

1	B2:	Is there any way to move some of the notes around for cluster 1? ... Like change the order of the bullet points.
2	B2:	I think `"Activities"` (topic note) should probably be at the top before the list of different activities.
3		*(S2 drags the topic note from the middle to the top of the cluster on Miro board.)*
4	S2:	I dragged it.
		...
5		*(B2 creates a topic note `"Meeting Strategies and tools"` for cluster 2 on Idea11y.)*
6	B2:	Can move back to the top of the section again.
7		*(S2 drags the topic note to the top of the cluster on Miro board.)*
8	S2:	Yeah, I moved it.



information conveyed through underlying visual grammar (e.g., gestalt principles [10], attention theory [76]) is neither systematically captured in the tool's metadata nor communicated through assistive technologies.

This accessibility gap extends beyond mere technical limitations to significant workflow disruptions for ability-diverse teams. Consider the practice of clustering sticky notes—an activity that enables convergent thinking and thematic mapping of generated ideas [59]. For sighted users, drag-and-drop is an easy and efficient mechanism to reposition sticky notes and discover latent relationship between them. For BLV users, however, not only is the mouse-based drag-and-drop action impossible to perform, but the task of moving sticky notes is also prohibitively time-consuming and impractical, as screen readers provide only directional feedback (left, right) without contextual information about the distance traveled, surrounding elements, or emerging spatial relationships. Thus, even when technically possible, such interactions require excessive time and cognitive effort for BLV users compared to their sighted peers, disrupting their creative flow [32, 103] and collaborative momentum.

In this regard, Idea11y presents an initial step toward accessible ideation technologies that can preserve creative and collaborative benefits of whiteboarding while fundamentally reconceptualizing its interaction paradigms. Rather than attempting to make the drag-and-drop process attainable with screen readers, Idea11y transforms the underlying clustering structure—based on spatial proximity, color similarity, or enclosure—into an hierarchical text outline that makes the implicit relationships between sticky notes explicit. When moving notes, BLV users receive clear contextual information about clusters and select destinations through intuitive dropdown menus, which supports the same convergent thinking goals but through accessible means. The system introduces purpose-driven interactions that preserve the intent behind whiteboarding actions while optimizing for nonvisual interaction, such as keystrokes to get a note's creator/color information, checkboxes to indicate preferences for ideas, quick navigation shortcuts to locate collaborators, and real-time alerts to perceive collaborators' co-presence and avoid concurrent edits.

Indeed, our findings revealed that with Idea11y, BLV participants engaged actively in all ideation phases—idea generation, synthesis, and evaluation—while coordinating with sighted collaborators who worked side-by-side on the whiteboard's freeform canvas space. This suggests opportunities for parallel system architectures where Idea11y and visual whiteboards maintain shared references, enabling both BLV and sighted collaborators to work within their preferred modality to contribute to unified creative outcomes. Therefore, we encourage researchers to develop technologies that fundamentally enhance creative thinking for BLV users, rather than retrofitting visual paradigms that may be inherently incompatible with nonvisual creative processes.

7.2 Practical Considerations for Accessible Collaborative Ideation Tools

Below we outline practical considerations for designing accessible collaborative ideation systems.

7.2.1 Facilitate spatial understanding of whiteboard content. Idea11y transforms the whiteboard's 2D canvas into a hierarchical list format which aligns with screen readers' linear reading flow but sacrifices important spatial details. Therefore, to help BLV users formulate a spatial mental map of the board, a two-way navigation between Idea11y and the whiteboard may be implemented. This way, a user can use keystrokes to directly jump from a bullet point in Idea11y's outline to the corresponding sticky note on the board and explore its horizontal/vertical neighbors using arrow keys [6], while jumping back to Idea11y from the whiteboard to explore the cluster layout. Moreover, the system can indicate relative spatial distances (e.g., "left, 3 columns/cm away from the nearest note") to help BLV users gather necessary contextual details for rearranging elements. Future work can also include multimodal interaction, such as spatial audio for conveying relative locations [31, 89], vibrotactile feedback on touchscreen devices [128, 129], tactile print-outs of whiteboard layouts [72, 80], and AI assistants or conversational agents for speech-triggered navigation [78, 108, 123].

7.2.2 Enable nonvisual representation of visual signals. Idea11y converts some of the implicit visual signals on whiteboards into accessible formats for BLV users, e.g., mapping colors or creators to distinct voices and allowing pull requests to directly get this information. Future work can go beyond merely announcing the color/creator information to provide interpretive explanation, such as using visual reasoning models to analyze the visual emphasis of each idea (e.g., by note size/color) and allowing BLV users to be aware of the most preferred ideas or most active regions. However, this can get challenging when visual attributes communicate different meanings e.g., colors may denote priority, creator, or category. The system could apply different mechanisms to interpret visual cues on smaller units (e.g., frames) and adapt to users' intent as they evolve throughout different ideation stages.

7.2.3 Support accessible generation, expansion, and evaluation of ideas. Our analysis showed how Idea11y assisted BLV users in expressing ideas by reducing accessibility barriers in creating, manipulating, and repositioning notes. Moving forward, we recognize opportunities to go beyond lowering technological frictions to enhance creative thinking. Taking the cluster structure of Idea11y as an example, future systems can use generative AI to help users merge ideas, recommend similar concepts within a cluster, or suggest adding different ideas across clusters [44, 113]. Such prompting techniques and outcomes must be made accessible to BLV users by clearly differentiating the user- and AI-generated ideas and offering easy mechanisms to accept or dismiss recommendations. To better support convergent thinking, future systems could expand Idea11y's binary voting mechanism to capture users' detailed reactions through comments [66] anchored to a specific note, cluster, or other open areas on the board. The comments could be augmented with voice coding and non-speech auditory cues to differentiate those from the original ideas and convey who commented what and where [40].

7.3 Limitations and Future Work

Idea11y identifies content clusters by applying gestalt principles [10] of proximity, similarity, and enclosure, as this is a common clustering practice during brainstorming and affinity diagramming [84]. However, other complex layouts (e.g., fishbone diagram, mind map) and workflows (e.g., storyboarding) may require different algorithms to make these whiteboard structures accessible. Furthermore, we evaluated Idea11y with a small sample, including BLV-sighted *dyads*. Future work should evaluate ideation systems with ability-diverse teams of varied size and composition to simulate more realistic and diverse ideation scenarios.

8 Conclusion

This work focuses on augmenting accessible collaborative ideation between BLV and sighted users on digital whiteboards. Through formative interviews with sighted whiteboard users, we identified a set of ideation practices that require accessibility support. Drawing on this, we built Idea11y that transforms freeform whiteboard content into a hierarchical, cluster-based, and editable text outline combined with screen reader-compatible navigational cues and auditory feedback. Evaluation with thirteen BLV users and six BLV-sighted dyads demonstrated Idea11y's effectiveness in supporting idea generation, synthesis, and evaluation and revealed how BLV participants used Idea11y to collaborate and coordinate actions with sighted peers. These findings encourage us to rethink established visual-centric creativity support frameworks and highlight design opportunities for future accessible collaborative ideation technologies.

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References

[1] [n.d.]. All your customer insights in one place. https://condens.io/
[2] [n.d.]. Build and deploy on the AI Cloud. https://vercel.com/
[3] [n.d.]. Fast-track innovation with Miro AI. https://miro.com/ai/
[4] [n.d.]. FigJam. https://www.figma.com/figjam/
[5] [n.d.]. Google Jamboard. https://jamboard.google.com/
[6] [n.d.]. Keyboard navigation while working on boards. https://help.miro.com/hc/en-us/articles/11997028019858-Keyboard-navigation-while-working-on-boards
[7] [n.d.]. Make your app the best it can be with Firebase and generative AI. https://firebase.google.com/
[8] [n.d.]. Overview of Miro Accessibility. https://help.miro.com/hc/en-us/articles/19506114302354-Overview-of-Miro-Accessibility Retrieved July 10, 2025.

[9] [n.d.]. Redesign the way you jam with FigJam AI. https://www.figma.com/figjam/ai/
[10] [n.d.]. The Gestalt Principles. https://www.interaction-design.org/literature/topics/gestalt-principles Retrieved July 10, 2025.
[11] [n.d.]. Use FigJam with a screen reader. https://help.figma.com/hc/en-us/articles/14477051168791-Use-FigJam-with-a-screen-reader Retrieved July 10, 2025.
[12] 2010. Flask. https://flask.palletsprojects.com/en/stable/
[13] 2023. Web Speech API. https://developer.mozilla.org/en-US/docs/Web/API/Web_Speech_API
[14] 2024. Miro Accessibility. https://miro.com/accessibility-statement/improvements/
[15] 2024. The Miro Web SDK. https://developers.miro.com/docs/miro-web-sdk-introduction
[16] 2025. The AI PaaS For Deploying, Managing, and Scaling Apps. https://www.heroku.com/
[17] Taslima Akter, Aparajita S. Marathe, Darren Gergle, and Anne Marie Piper. 2025. Beyond Accessibility: Understanding the Ease of Use and Impacts of Digital Collaboration Tools for Blind and Low Vision Workers. In *Proceedings of the 27th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '25)* (Denver, CO, USA). ACM, Denver, CO, USA, 1–26. https://doi.org/10.1145/3663547.3746332
[18] Mrim Alnfiai and Wajdi Alhakami. 2021. The accessibility of Taif University blackboard for visually impaired students. *International Journal of Computer Science & Network Security* 21, 6 (2021), 258–268.
[19] Salvatore Andolina, Hendrik Schneider, Joel Chan, Khalil Klouche, Giulio Jacucci, and Steven Dow. 2017. Crowdboard: Augmenting In-Person Idea Generation with Real-Time Crowds. In *Proceedings of the 2017 ACM SIGCHI Conference on Creativity and Cognition* (Singapore, Singapore) *(C&C '17)*. Association for Computing Machinery, New York, NY, USA, 106–118. https://doi.org/10.1145/3059454.3059477
[20] Ronald M. Baecker, Dimitrios Nastos, Ilona R. Posner, and Kelly L. Mawby. 1993. The user-centered iterative design of collaborative writing software. In *Proceedings of the INTERACT '93 and CHI '93 Conference on Human Factors in Computing Systems* (Amsterdam, The Netherlands) *(CHI '93)*. Association for Computing Machinery, New York, NY, USA, 399–405. https://doi.org/10.1145/169059.169312
[21] Mark S. Baldwin, Jennifer Mankoff, Bonnie Nardi, and Gillian Hayes. 2020. An Activity Centered Approach to Nonvisual Computer Interaction. *ACM Trans. Comput.-Hum. Interact.* 27, 2, Article 12 (March 2020), 27 pages. https://doi.org/10.1145/3374211
[22] Linden J. Ball and Bo T. Christensen. 2020. Chapter 2 - How sticky notes support cognitive and socio-cognitive processes in the generation and exploration of creative ideas. In *Sticky Creativity*, Bo T. Christensen, Kim Halskov, and Clemens N. Klokmose (Eds.). Academic Press, 19–51. https://doi.org/10.1016/B978-0-12-816566-9.00002-1
[23] Linden J. Ball, Bo T. Christensen, and Kim Halskov. 2021. Sticky notes as a kind of design material: How sticky notes support design cognition and design collaboration. *Design Studies* 76 (2021), 101034. https://doi.org/10.1016/j.destud.2021.101034
[24] Cynthia L. Bennett, Erin Brady, and Stacy M. Branham. 2018. Interdependence as a Frame for Assistive Technology Research and Design. In *Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility* (Galway, Ireland) *(ASSETS '18)*. Association for Computing Machinery, New York, NY, USA, 161–173. https://doi.org/10.1145/3234695.3236348
[25] Hanisha Besant. 2016. The Journey of Brainstorming. *Journal of Transformative Innovation* 2, 1 (2016), 1–7. https://www.regent.edu/acad/global/publications/jti/vol2iss1/Besant_JTISU16A.pdf
[26] Nanyi Bi, Yueh-Chi Chi, Yun-Yun Lin, Min-Jui Lee, and Bing-Yu Chen. 2024. Blow Your Mind: Exploring the Effects of Scene-Switching and Visualization of Time Constraints on Brainstorming in Virtual Reality. *Proc. ACM Hum.-Comput. Interact.* 8, CSCW2, Article 487 (Nov. 2024), 23 pages. https://doi.org/10.1145/3687026
[27] Stacy Branham, Gene Golovchinsky, Scott Carter, and Jacob T. Biehl. 2010. Let's Go from the Whiteboard: Supporting Transitions in Work through Whiteboard Capture and Reuse. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) *(CHI '10)*. ACM, New York, NY, USA, 75–84. https://doi.org/10.1145/1753326.1753338
[28] Virginia Braun and Victoria Clarke. 2021. *Thematic Analysis: A Practical Guide*. Sage Publications.
[29] Willemijn Brouwer. 2020. Geneplore: Theory Ready for Practical Use. https://www.creativityn.com/publication/cq20-geneplore-theory-ready-for-practical-use/
[30] Zoya Bylinskii, Nam Wook Kim, Peter O'Donovan, Sami Alsheikh, Spandan Madan, Hanspeter Pfister, Fredo Durand, Bryan Russell, and Aaron Hertzmann. 2017. Learning Visual Importance for Graphic Designs and Data Visualizations. In *Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology* (Québec City, QC, Canada) *(UIST '17)*. Association for Computing Machinery, New York, NY, USA, 57–69. https://doi.org/10.1145/3126594.3126653
[31] Ruei-Che Chang, Chia-Sheng Hung, Bing-Yu Chen, Dhruv Jain, and Anhong Guo. 2024. SoundShift: Exploring Sound Manipulations for Accessible Mixed-Reality Awareness. In *Proceedings of the 2024 ACM Designing Interactive Systems Conference* (Copenhagen, Denmark) *(DIS '24)*. Association for Computing Machinery, New York, NY, USA, 116–132. https://doi.org/10.1145/3643834.3661556
[32] Erin Cherry and Celine Latulipe. 2014. Quantifying the Creativity Support of Digital Tools through the Creativity Support Index. *ACM Trans. Comput.-Hum. Interact.* 21, 4, Article 21 (June 2014), 25 pages. https://doi.org/10.1145/2617588
[33] Mauro Cherubini, Gina Venolia, Rob DeLine, and Amy J. Ko. 2007. Let's go to the whiteboard: how and why software developers use drawings. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (San Jose, California, USA) *(CHI '07)*. Association for Computing Machinery, New York, NY, USA, 557–566. https://doi.org/10.1145/1240624.1240714
[34] DaEun Choi, Sumin Hong, Jeongeon Park, John Joon Young Chung, and Juho Kim. 2024. CreativeConnect: Supporting Reference Recombination for Graphic Design Ideation with Generative AI. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 1055, 25 pages. https://doi.org/10.1145/3613904.3642794
[35] Bo T. Christensen and Morten Friis-Olivarius. 2020. Chapter 3 - How do initial ideas evolve into final ones? Exploring the cognitive size, structure and life of ideas using sticky notes. In *Sticky Creativity*, Bo T. Christensen, Kim Halskov, and Clemens N. Klokmose (Eds.). Academic Press, 53–75. https://doi.org/10.1016/B978-0-12-816566-9.00003-3
[36] John Joon Young Chung, Shiqing He, and Eytan Adar. 2021. The Intersection of Users, Roles, Interactions, and Technologies in Creativity Support Tools. In *Proceedings of the 2021 ACM Designing Interactive Systems Conference* (Virtual Event, USA) *(DIS '21)*. Association for Computing Machinery, New York, NY, USA, 1817–1833. https://doi.org/10.1145/3461778.3462050
[37] Andrew Clayphan, Anthony Collins, Christopher Ackad, Bob Kummerfeld, and Judy Kay. 2011. Firestorm: A Brainstorming Application for Collaborative Group Work at Tabletops. In *Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces* (Kobe, Japan) *(ITS '11)*. ACM, New York, NY, USA, 162–171. https://doi.org/10.1145/2076354.2076386
[38] Maitraye Das, Darren Gergle, and Anne Marie Piper. 2019. "It doesn't win you friends": Understanding Accessibility in Collaborative Writing for People with Vision Impairments. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (2019), 26. https://doi.org/10.1145/3359293
[39] Maitraye Das, Thomas Barlow McHugh, Anne Marie Piper, and Darren Gergle. 2022. Co11ab: Augmenting Accessibility in Synchronous Collaborative Writing for People with Vision Impairments. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI '22)*. Association for Computing Machinery, New York, NY, USA, Article 196, 18 pages. https://doi.org/10.1145/3491102.3501918
[40] Maitraye Das, Anne Marie Piper, and Darren Gergle. 2022. Design and Evaluation of Accessible Collaborative Writing Techniques for People with Vision Impairments. *ACM Trans. Comput.-Hum. Interact.* 29, 2, Article 9 (Jan. 2022), 42 pages. https://doi.org/10.1145/3480169
[41] Maitraye Das, Abigale Stangl, and Leah Findlater. 2024. "That comes with a huge career cost:" Understanding Collaborative Ideation Experiences of Disabled Professionals. 8, CSCW1, Article 179 (April 2024), 28 pages. https://doi.org/10.1145/3641018
[42] Carsten Deckert, Ahmed Mohya, and Sujieban Suntharalingam. 2021. VIRTUAL WHITEBOARDS & DIGITAL POST-ITS - INCORPORATING INTERNET-BASED TOOLS FOR IDEATION INTO ENGINEERING COURSES.
[43] Sharon J. Derry, Roy D. Pea, Brigid Barron, Randi A. Engle, Frederick Erickson, Ricki Goldman, Rogers Hall, Timothy Koschmann, Jay L. Lemke, Miriam Gamoran Sherin, and Bruce L. Sherin. 2010. Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics. *Journal of the Learning Sciences* 19, 1 (2010), 3–53. https://doi.org/10.1080/10508400903452884
[44] Giulia Di Fede, Davide Rocchesso, Steven P. Dow, and Salvatore Andolina. 2022. The Idea Machine: LLM-based Expansion, Rewriting,

Combination, and Suggestion of Ideas. In *Proceedings of the 14th Conference on Creativity and Cognition* (Venice, Italy) *(C&C '22)*. Association for Computing Machinery, New York, NY, USA, 623–627. https://doi.org/10.1145/3527927.3535197

[45] Martin Ester, Hans-Peter Kriegel, Jörg Sander, and Xiaowei Xu. 1996. A density-based algorithm for discovering clusters in large spatial databases with noise. In *Proceedings of the Second International Conference on Knowledge Discovery and Data Mining* (Portland, Oregon) *(KDD'96)*. AAAI Press, 226–231.

[46] Danyang Fan, Kate Glazko, and Sean Follmer. 2022. *Accessibility of Linked-Node Diagrams on Collaborative Whiteboards for Screen Reader Users: Challenges and Opportunities*. Springer International Publishing, Cham, 97–108. https://doi.org/10.1007/978-3-031-09297-8_6

[47] Haakon Faste, Nir Rachmel, Russell Essary, and Evan Sheehan. 2013. Brainstorm, Chainstorm, Cheatstorm, Tweetstorm: New Ideation Strategies for Distributed HCI Design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Paris, France) *(CHI '13)*. ACM, New York, NY, USA, 1343–1352. https://doi.org/10.1145/2470654.2466177

[48] K. J. Kevin Feng, Tony W Li, and Amy X. Zhang. 2023. Understanding Collaborative Practices and Tools of Professional UX Practitioners in Software Organizations. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. ACM, New York, NY, USA, Article 764, 20 pages. https://doi.org/10.1145/3544548.3581273

[49] Claire Ferrari and Amy Hurst. 2021. Accessible Web Development: Opportunities to Improve the Education and Practice of web Development with a Screen Reader. *ACM Trans. Access. Comput.* 14, 2, Article 8 (July 2021), 32 pages. https://doi.org/10.1145/3458024

[50] Ronald A. Finke. 1996. Imagery, Creativity, and Emergent Structure. *Consciousness and Cognition* 5, 3 (1996), 381–393. https://doi.org/10.1006/ccog.1996.0024

[51] Ronald A Finke, Thomas B Ward, and Steven M Smith. 1992. *Creative cognition: Theory, research, and applications*. MIT press. https://doi.org/10.7551/mitpress/7722.001.0001

[52] Aron D. Fischel and Kim Halskov. 2020. Chapter 9 - A framework for sticky note information management. In *Sticky Creativity*, Bo T. Christensen, Kim Halskov, and Clemens N. Klokmose (Eds.). Academic Press, 199–230. https://doi.org/10.1016/B978-0-12-816566-9.00009-4

[53] André P Freire, Flávia Linhalis, Sandro L Bianchini, Renata PM Fortes, and Maria da Graça C Pimentel. 2010. Revealing the whiteboard to blind students: An inclusive approach to provide mediation in synchronous e-learning activities. *Computers & Education* 54, 4 (2010), 866–876.

[54] Jonas Frich, Michael Mose Biskjaer, and Peter Dalsgaard. 2018. Twenty Years of Creativity Research in Human-Computer Interaction: Current State and Future Directions. In *Proceedings of the 2018 Designing Interactive Systems Conference (DIS '18)*. ACM, Hong Kong, China, 1235–1257. https://doi.org/10.1145/3196709.3196732

[55] Jonas Frich, Lindsay MacDonald Vermeulen, Christian Remy, Michael Mose Biskjaer, and Peter Dalsgaard. 2019. Mapping the Landscape of Creativity Support Tools in HCI. In *Proceedings of the 2019 Conference on Human Factors in Computing Systems (CHI '19)*. ACM, Glasgow, Scotland UK, 18. https://doi.org/10.1145/3290605.3300619

[56] Harsh Gandhi, Brian Wanamaker, Andrew Kulowski, Chetan Jaiswal, Kruti Shah, Brian O'Neill, and Sara Rzeszutek. 2025. AirBoard: An AI Powered Whiteboard. In *2025 IEEE World AI IoT Congress (AIIoT)*. IEEE, 0333–0339.

[57] Sourojit Ghosh and Sarah Coppola. 2022. Reflecting on Hybrid Learning in Studio-based Courses: Complications and Effectiveness during the Pandemic and Beyond. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, Vol. 66. SAGE Publications Sage CA: Los Angeles, CA, 2108–2112.

[58] David Gonçalves, André Rodrigues, Mike L. Richardson, Alexandra A. de Sousa, Michael J. Proulx, and Tiago Guerreiro. 2021. Exploring Asymmetric Roles in Mixed-Ability Gaming. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 114, 14 pages. https://doi.org/10.1145/3411764.3445494

[59] Joy Paul Guilford. 1950. Creativity. *American Psychologist* 5, 9 (1950), 444–454. https://doi.org/10.1037/h0063487

[60] Carl Gutwin and Saul Greenberg. 2002. A Descriptive Framework of Workspace Awareness for Real-Time Groupware. *Computer Supported Cooperative Work (CSCW)* 11, CSCW (2002), 411–446. https://doi.org/10.1023/A:1021271517844

[61] Aimi Hamraie and Kelly Fritsch. 2019. Crip Technoscience Manifesto. *Catalyst: Feminism, Theory, Technoscience* 5, 1 (2019), 1–33. https://catalystjournal.org/index.php/catalyst/article/view/29607

[62] Jessica He, Stephanie Houde, Gabriel E. Gonzalez, Darío Andrés Silva Moran, Steven I. Ross, Michael Muller, and Justin D. Weisz. 2024. AI and the Future of Collaborative Work: Group Ideation with an LLM in a Virtual Canvas. In *Proceedings of the 3rd Annual Meeting of the Symposium on Human-Computer Interaction for Work* (Newcastle upon Tyne, United Kingdom) *(CHIWORK '24)*. Association for Computing Machinery, New York, NY, USA, Article 9, 14 pages. https://doi.org/10.1145/3663384.3663398

[63] Otmar Hilliges, Lucia Terrenghi, Sebastian Boring, David Kim, Hendrik Richter, and Andreas Butz. 2007. Designing for Collaborative Creative Problem Solving. In *Proceedings of the 6th ACM SIGCHI Conference on Creativity & Cognition* (Washington, DC, USA) *(C&C '07)*. ACM, New York, NY, USA, 137–146. https://doi.org/10.1145/1254960.1254980

[64] Erzhen Hu, Mingyi Li, Jungtaek Hong, Xun Qian, Alex Olwal, David Kim, Seongkook Heo, and Ruofei Du. 2025. Thing2Reality: Enabling Spontaneous Creation of 3D Objects from 2D Content using Generative AI in XR Meetings. In *Proceedings of the 38th Annual ACM Symposium on User Interface Software and Technology (UIST '25)*. Association for Computing Machinery, New York, NY, USA, Article 53, 16 pages. https://doi.org/10.1145/3746059.3747621

[65] Bernd Huber, Stuart Shieber, and Krzysztof Z. Gajos. 2019. Automatically Analyzing Brainstorming Language Behavior with Meeter. *Proc. ACM Hum.-Comput. Interact.* 3, CSCW, Article 30 (Nov. 2019), 17 pages. https://doi.org/10.1145/3359132

[66] Mina Huh, YunJung Lee, Dasom Choi, Haesoo Kim, Uran Oh, and Juho Kim. 2022. Cocomix: Utilizing Comments to Improve Non-Visual Webtoon Accessibility. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI '22)*. Association for Computing Machinery, New York, NY, USA, Article 607, 18 pages. https://doi.org/10.1145/3491102.3502081

[67] Edwin Hutchins. 2005. Material anchors for conceptual blends. *Journal of Pragmatics* 37, 10 (2005), 1555–1577. https://doi.org/10.1016/j.pragma.2004.06.008 Conceptual Blending Theory.

[68] Mads Møller Jensen, Roman Rädle, Clemens N. Klokmose, and Susanne Bodker. 2018. Remediating a Design Tool: Implications of Digitizing Sticky Notes. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI '18)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3173574.3173798

[69] Emily K. Johnson. 2022. Miro, Miro: Student Perceptions of a Visual Discussion Board. In *Proceedings of the 40th ACM International Conference on Design of Communication* (Boston, MA, USA) *(SIGDOC '22)*. ACM, New York, NY, USA, 96–101. https://doi.org/10.1145/3513130.3558983

[70] Sara Adel Kabil and Namrah Ilyas. 2023. The Role of Online Whiteboard Tools in Supporting Collaborative Learning, Learning Experience, and Satisfaction in the Online Classroom. *International Journal of Technologies in Learning* 30, 2 (1 Jan. 2023), 23–49. https://doi.org/10.18848/2327-0144/cgp/v30i02/23-49

[71] Shipra Kayan. 2024. How to get started with visual thinking: Diversify your brainstorm sessions with these visual thinking techniques. https://miro.com/blog/creativity-visual-thinking/ Retrieved August 19, 2025.

[72] Gyeongdeok Kim, Chungman Lim, and Gunhyuk Park. 2025. I-Scratch: Independent Slide Creation With Auditory Comment and Haptic Interface for the Blind and Visually Impaired. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems (CHI '25)*. Association for Computing Machinery, New York, NY, USA, Article 1161, 23 pages. https://doi.org/10.1145/3706598.3713553

[73] Janin Koch, Nicolas Taffin, Michel Beaudouin-Lafon, Markku Laine, Andrés Lucero, and Wendy E. Mackay. 2020. ImageSense: An Intelligent Collaborative Ideation Tool to Support Diverse Human-Computer Partnerships. *Proc. ACM Hum.-Comput. Interact.* 4, CSCW1, Article 45 (May 2020), 27 pages. https://doi.org/10.1145/3392850

[74] Janin Koch, Nicolas Taffin, Andrés Lucero, and Wendy E. Mackay. 2020. SemanticCollage: Enriching Digital Mood Board Design with Semantic Labels. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS '20)*. Association for Computing Machinery, New York, NY, USA, 407–418. https://doi.org/10.1145/3357236.3395494

[75] Amanda Rybin Koob, Kathia Salomé Ibacache Oliva, Michael Williamson, Marisha Lamont-Manfre, Addison Hugen, and Amelia Dickerson. 2022. Tech tools in pandemic-transformed information literacy instruction: Pushing for digital accessibility. *Information Technology and Libraries* 41, 4 (2022).

[76] John K Kruschke. 2003. Attention in learning. *Current Directions in Psychological Science* 12, 5 (2003), 171–175.

[77] Cheuk Yin Phipson Lee, Zhuohao Zhang, Jaylin Herskovitz, JooYoung Seo, and Anhong Guo. 2022. CollabAlly: Accessible Collaboration Awareness in Document Editing. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI '22)*. Association for Computing Machinery, New York, NY, USA, Article 596, 17 pages. https://doi.org/10.1145/3491102.3517635

[78] Gippeum Lee and Namchoon Park. 2025. Just Talk, and Sticky Notes will be Created: Towards Collaborative Dialogue in Face-to-Face Workshops the Experiment with a Generative AI-Based. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '25)*. Association for Computing Machinery, New York, NY, USA, Article 363, 6 pages. https://doi.org/10.1145/3706599.3720231

[79] Joon Hyub Lee, Donghyeok Ma, Haena Cho, and Seok-Hyung Bae. 2021. Post-Post-it: A Spatial Ideation System in VR for Overcoming Limitations of Physical Post-it Notes. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI EA '21)*. Association for Computing Machinery, New York, NY, USA, Article 300, 7 pages. https://doi.org/10.1145/3411763.3451786

[80] Jingyi Li, Son Kim, Joshua A. Miele, Maneesh Agrawala, and Sean Follmer. 2019. Editing Spatial Layouts through Tactile Templates for People with Visual Impairments. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–11. https://doi.org/10.1145/3290605.3300436

[81] Qingchuan Li, Jiaxin Zhang, Xin Xie, and Yan Luximon. 2021. How Shared Online Whiteboard Supports Online Collaborative Design Activities: A Social Interaction Perspective. In *Advances in Creativity, Innovation, Entrepreneurship and Communication of Design*, Evangelos Markopoulos, Ravindra S. Goonetilleke, Amic G. Ho, and Yan Luximon (Eds.). Springer International Publishing, Cham, 285–293.

[82] David Chuan-En Lin, Hyeonsu B. Kang, Nikolas Martelaro, Aniket Kittur, Yan-Ying Chen, and Matthew K. Hong. 2025. Inkspire: Supporting Design Exploration with Generative AI through Analogical Sketching. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems (CHI '25)*. Association for Computing Machinery, New York, NY, USA, Article 427, 18 pages. https://doi.org/10.1145/3706598.3713397

[83] Paul Benjamin Lowry, Aaron Curtis, and Michelle René Lowry. 2004. Building a Taxonomy and Nomenclature of Collaborative Writing to Improve Interdisciplinary Research and Practice. *The Journal of Business Communication (1973)* 41, 1 (2004), 66–99. https://doi.org/10.1177/0021943603259363

[84] Andrés Lucero. 2015. Using affinity diagrams to evaluate interactive prototypes. In *Human-Computer Interaction–INTERACT 2015: 15th IFIP TC 13 International Conference, Bamberg, Germany, September 14-18, 2015, Proceedings, Part II 15*. Springer, 231–248. https://doi.org/10.1007/978-3-319-22668-2_19

[85] Yossi Maaravi, Ben Heller, Yael Shoham, Shay Mohar, and Baruch Deutsch. 2021. Ideation in the digital age: literature review and integrative model for electronic brainstorming. *Review of Managerial Science* 15, 6 (2021), 1431–1464. https://doi.org/10.1007/s11846-020-00400-5

[86] Nicolas Mangano, Thomas D. LaToza, Marian Petre, and André van der Hoek. 2014. Supporting Informal Design with Interactive Whiteboards. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Toronto, Ontario, Canada) *(CHI '14)*. ACM, New York, NY, USA, 331–340. https://doi.org/10.1145/2556288.2557411

[87] Daniel Mendes, Sofia Reis, João Guerreiro, and Hugo Nicolau. 2020. Collaborative Tabletops for Blind People: The Effect of Auditory Design on Workspace Awareness. *Proc. ACM Hum.-Comput. Interact.* 4, ISS, Article 197 (Nov. 2020), 19 pages. https://doi.org/10.1145/3427325

[88] Oussama Metatla, Nick Bryan-Kinns, Tony Stockman, and Fiore Martin. 2012. Cross-modal Collaborative Interaction between Visually-impaired and Sighted Users in the Workplace. In *Proceedings of the 18th International Conference on Auditory Display* (Atlanta, GA, USA) *(ICAD '12)*.

[89] Vishnu Nair, Shao-en Ma, Ricardo E. Gonzalez Penuela, Yicheng He, Karen Lin, Mason Hayes, Hannah Huddleston, Matthew Donnelly, and Brian A. Smith. 2022. Uncovering Visually Impaired Gamers' Preferences for Spatial Awareness Tools Within Video Games. In *Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility* (Athens, Greece) *(ASSETS '22)*. Association for Computing Machinery, New York, NY, USA, Article 6, 16 pages. https://doi.org/10.1145/3517428.3544802

[90] Vishnu Nair, Hanxiu 'Hazel' Zhu, Peize Song, Jizhong Wang, and Brian A. Smith. 2024. Surveyor: Facilitating Discovery Within Video Games for Blind and Low Vision Players. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 10, 15 pages. https://doi.org/10.1145/3613904.3642615

[91] Michael A. Nees and Eliana Liebman. 2023. Auditory Icons, Earcons, Spearcons, and Speech: A Systematic Review and Meta-Analysis of Brief Audio Alerts in Human-Machine Interfaces. *Auditory Perception & Cognition* 6, 3–4 (2023), 300–329. https://doi.org/10.1080/25742442.2023.2219201

[92] Robin Neuhaus, Ronda Ringfort-Felner, Daniel Courtney, Madlen Kneile, and Marc Hassenzahl. 2024. Virtual Unreality: Augmentation-Oriented Ideation Through Design Cards. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 608, 23 pages. https://doi.org/10.1145/3613904.3642364

[93] Beatrice Jia Min Ng, Jia Yi Han, Yongbeom Kim, Kenzo Aki Togo, Jia Ying Chew, Yulin Lam, and Fun Man Fung. 2021. Supporting social and learning presence in the revised community of inquiry framework for hybrid learning. *Journal of Chemical Education* 99, 2 (2021), 708–714.

[94] Alex F. Osborn. 1953. *Applied Imagination.* Charles Scribner's Sons, New York, NY, USA.

[95] Srishti Palani, Yingyi Zhou, Sheldon Zhu, and Steven P. Dow. 2022. InterWeave: Presenting Search Suggestions in Context Scaffolds Information Search and Synthesis. In *Proceedings of the 35th Annual ACM Symposium on User Interface Software and Technology* (Bend, OR, USA) *(UIST '22)*. Association for Computing Machinery, New York, NY, USA, Article 93, 16 pages. https://doi.org/10.1145/3526113.3545696

[96] Maulishree Pandey, Vaishnav Kameswaran, Hrishikesh V. Rao, Sile O'Modhrain, and Steve Oney. 2021. Understanding Accessibility and Collaboration in Programming for People with Visual Impairments. *Proceedings of the ACM on Human-Computer Interaction* 5, CSCW1, Article 129 (apr 2021), 30 pages. https://doi.org/10.1145/3449203

[97] Yi-Hao Peng, Peggy Chi, Anjuli Kannan, Meredith Ringel Morris, and Irfan Essa. 2023. Slide Gestalt: Automatic Structure Extraction in Slide Decks for Non-Visual Access. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 829, 14 pages. https://doi.org/10.1145/3544548.3580921

[98] Yi-Hao Peng, Jason Wu, Jeffrey Bigham, and Amy Pavel. 2022. Diffscriber: Describing Visual Design Changes to Support Mixed-Ability Collaborative Presentation Authoring. In *Proceedings of the 35th Annual ACM Symposium on User Interface Software and Technology* (Bend, OR, USA) *(UIST '22)*. Association for Computing Machinery, New York, NY, USA, Article 35, 13 pages. https://doi.org/10.1145/3526113.3545637

[99] Matthew Peveler, Jeramey Tyler, Dacoda B. Nelson, Renato Cerqueira, and Hui Su. 2020. Browser Based Digital Sticky Notes for Design Thinking. In *Companion Publication of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS' 20 Companion)*. Association for Computing Machinery, New York, NY, USA, 349–352. https://doi.org/10.1145/3393914.3395824

[100] Venkatesh Potluri, Maulishree Pandey, Andrew Begel, Michael Barnett, and Scott Reitherman. 2022. CodeWalk: Facilitating Shared Awareness in Mixed-Ability Collaborative Software Development. In *Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility* (Athens, Greece) *(ASSETS '22)*. Association for Computing Machinery, New York, NY, USA, Article 20, 16 pages. https://doi.org/10.1145/3517428.3544812

[101] Venkatesh Potluri, Sudheesh Singanamalla, Nussara Tieanklin, and Jennifer Mankoff. 2023. Notably Inaccessible — Data Driven Understanding of Data Science Notebook (In)Accessibility. In *Proceedings of the 25th International ACM SIGACCESS Conference on Computers and Accessibility* (New York, NY, USA) *(ASSETS '23)*. Association for Computing Machinery, New York, NY, USA, Article 13, 19 pages. https://doi.org/10.1145/3597638.3608417

[102] Jude Rayan, Dhruv Kanetkar, Yifan Gong, Yuewen Yang, Srishti Palani, Haijun Xia, and Steven P. Dow. 2024. Exploring the Potential for Generative AI-based Conversational Cues for Real-Time Collaborative Ideation. In *Proceedings of the 16th Conference on Creativity & Cognition* (Chicago, IL, USA) *(C&C '24)*. Association for Computing Machinery, New York, NY, USA, 117–131. https://doi.org/10.1145/3635636.3656184

[103] Jenni L. Redifer, Christine L. Bae, and Morgan DeBusk-Lane. 2019. Implicit Theories, Working Memory, and Cognitive Load: Impacts on Creative Thinking. *SAGE Open* 9, 1 (2019), 2158244019835919. https://doi.org/10.1177/2158244019835919 arXiv:https://doi.org/10.1177/2158244019835919

[104] Elsa Aniela Mendez Reguera and Mildred Lopez. 2021. Using a digital whiteboard for student engagement in distance education. *Computers & electrical engineering* 93 (2021), 107268.

[105] Filipa Rocha, Hugo Simão, João Nogueira, Isabel Neto, Tiago Guerreiro, and Hugo Nicolau. 2025. Awareness in Collaborative Mixed-Visual Ability

Tangible Programming Activities. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems (CHI '25)*. Association for Computing Machinery, New York, NY, USA, Article 1146, 15 pages. https://doi.org/10.1145/3706598.3713610
[106] Theerasak Rojanarata. 2020. How Online Whiteboard Promotes Students' Collaborative Skills in Laboratory Learning. In *Proceedings of the 2020 8th International Conference on Information and Education Technology* (Okayama, Japan) *(ICIET 2020)*. ACM, New York, NY, USA, 68–72. https://doi.org/10.1145/3395245.3396433
[107] Emilia Rosselli Del Turco, Nanna Inie, James D. Hollan, and Peter Dalsgaard. 2025. How Creative Practitioners Use Tools to Capture Ideas: A Cross-Domain Study. *ACM Trans. Comput.-Hum. Interact.* (April 2025). https://doi.org/10.1145/3727979
[108] John Rudnik, Sharadhi Raghuraj, Mingyi Li, and Robin N. Brewer. 2024. CareJournal: A Voice-Based Conversational Agent for Supporting Care Communications. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 526, 22 pages. https://doi.org/10.1145/3613904.3642163
[109] Elizabeth Sanders and Colin William. 2002. Harnessing people's creativity: Ideation and expression through visual communication. In *Focus Groups*. CRC Press, 137–148.
[110] Elizabeth B.-N. Sanders and Pieter Jan Stappers. 2008. Co-creation and the New Landscapes of Design. *CoDesign* 4, 1 (2008), 5–18. https://doi.org/10.1080/15710880701875068
[111] Lucila Santarosa, Débora Conforto, and Rodrigo Prestes Machado. 2014. Whiteboard: Synchronism, accessibility, protagonism and collective authorship for human diversity on Web 2.0. *Computers in Human Behavior* 31 (2014), 591–601.
[112] Matthew Seita, Sooyeon Lee, Sarah Andrew, Kristen Shinohara, and Matt Huenerfauth. 2022. Remotely Co-Designing Features for Communication Applications using Automatic Captioning with Deaf and Hearing Pairs. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI '22)*. Association for Computing Machinery, New York, NY, USA, Article 460, 13 pages. https://doi.org/10.1145/3491102.3501843
[113] Orit Shaer, Angelora Cooper, Osnat Mokryn, Andrew L Kun, and Hagit Ben Shoshan. 2024. AI-Augmented Brainwriting: Investigating the use of LLMs in group ideation. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 1050, 17 pages. https://doi.org/10.1145/3613904.3642414
[114] Yang Shi, Yang Wang, Ye Qi, John Chen, Xiaoyao Xu, and Kwan-Liu Ma. 2017. IdeaWall: Improving Creative Collaboration through Combinatorial Visual Stimuli. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (Portland, Oregon, USA) *(CSCW '17)*. ACM, New York, NY, USA, 594–603. https://doi.org/10.1145/2998181.2998208
[115] Ben Shneiderman. 2007. Creativity support tools: accelerating discovery and innovation. *Commun. ACM* 50, 12 (Dec. 2007), 20–32. https://doi.org/10.1145/1323688.1323689
[116] Philip Strain and Stefano Baldan. 2024. Enhancing Accessibility in Collaborative Digital Whiteboards: A Demonstration of Innovative Features for Inclusive Real-Time Collaboration. In *Proceedings of the 26th International ACM SIGACCESS Conference on Computers and Accessibility* (St. John's, NL, Canada) *(ASSETS '24)*. Association for Computing Machinery, New York, NY, USA, Article 123, 3 pages. https://doi.org/10.1145/3663548.3688528
[117] Sangho Suh, Meng Chen, Bryan Min, Toby Jia-Jun Li, and Haijun Xia. 2024. Luminate: Structured Generation and Exploration of Design Space with Large Language Models for Human-AI Co-Creation. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 644, 26 pages. https://doi.org/10.1145/3613904.3642400
[118] Lauren Thevin, Nicolas Rodier, Bernard Oriola, Martin Hachet, Christophe Jouffrais, and Anke M. Brock. 2021. Inclusive Adaptation of Existing Board Games for Gamers with and without Visual Impairments using a Spatial Augmented Reality Framework for Touch Detection and Audio Feedback. *Proc. ACM Hum.-Comput. Interact.* 5, ISS, Article 505 (Nov. 2021), 33 pages. https://doi.org/10.1145/3488550
[119] Jakob Tholander and Martin Jonsson. 2023. Design Ideation with AI - Sketching, Thinking and Talking with Generative Machine Learning Models. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference* (Pittsburgh, PA, USA) *(DIS '23)*. Association for Computing Machinery, New York, NY, USA, 1930–1940. https://doi.org/10.1145/3563657.3596014
[120] UX Tools. 2024. Design Tool Survey. https://www.uxtools.co/survey/introduction/about-this-report Retrieved July 14, 2025.
[121] Danniel Varona-Marin, Jan A. Oberholzer, Edward Tse, and Stacey D. Scott. 2018. Post-Meeting Curation of Whiteboard Content Captured with Mobile Devices. In *Proceedings of the 2018 ACM International Conference on Interactive Surfaces and Spaces* (Tokyo, Japan) *(ISS '18)*. ACM, New York, NY, USA, 43–54. https://doi.org/10.1145/3279778.3279782
[122] Johan Wagemans. 2014. Historical and Conceptual Background: Gestalt Theory. In *Oxford Handbook of Perceptual Organization*, Johan Wagemans (Ed.). Oxford University Press, Chapter 1.
[123] Hao-Chuan Wang, Dan Cosley, and Susan R. Fussell. 2010. Idea expander: supporting group brainstorming with conversationally triggered visual thinking stimuli. In *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work* (Savannah, Georgia, USA) *(CSCW '10)*. Association for Computing Machinery, New York, NY, USA, 103–106. https://doi.org/10.1145/1718918.1718938
[124] Max Wertheimer. 1922. Untersuchungen zur Lehre von der Gestalt. *Psychologische Forschung* 1 (1922), 47–58. https://doi.org/10.1007/BF00410385
[125] Frank Wilcoxon, S. Katti, and Roberta A. Wilcox. 1970. Critical Values and Probability Levels for the Wilcoxon Rank Sum Test and the Wilcoxon Signed Rank Test. In *Selected Tables in Mathematical Statistics*. Vol. 1. American Mathematical Society, 171–259.
[126] Lan Xiao, Maryam Bandukda, Katrin Angerbauer, Weiyue Lin, Tigmanshu Bhatnagar, Michael Sedlmair, and Catherine Holloway. 2024. A Systematic Review of Ability-diverse Collaboration through Ability-based Lens in HCI. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 961, 21 pages. https://doi.org/10.1145/3613904.3641930
[127] Xiaotong (Tone) Xu, Jiayu Yin, Catherine Gu, Jenny Mar, Sydney Zhang, Jane L. E, and Steven P. Dow. 2024. Jamplate: Exploring LLM-Enhanced Templates for Idea Reflection. In *Proceedings of the 29th International Conference on Intelligent User Interfaces* (Greenville, SC, USA) *(IUI '24)*. Association for Computing Machinery, New York, NY, USA, 907–921. https://doi.org/10.1145/3640543.3645196
[128] Zhuohao (Jerry) Zhang and Jacob O. Wobbrock. 2023. A11yBoard: Making Digital Artboards Accessible to Blind and Low-Vision Users. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 55, 17 pages. https://doi.org/10.1145/3544548.3580655
[129] Yichun Zhao, Miguel A Nacenta, Mahadeo A. Sukhai, and Sowmya Somanath. 2024. TADA: Making Node-link Diagrams Accessible to Blind and Low-Vision People. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 45, 20 pages. https://doi.org/10.1145/3613904.3642222

A Participant Details

Table 7: Sighted participants in the formative study. P8 also attended BLV-sighted collaborative ideation session (S2 in Table 9).

ID	Professional Background	Years of Experience	Digital whiteboards Used	Whiteboarding Frequency
P1	Interaction design; product design; HCI/UX research; graphics, branding, and game design	> 5 yrs	Miro; FigJam; Lark/Feishu	Once in three months
P2	HCI/UX research	1–3 yrs	Miro; Google Jamboard	At least once a day
P3	Interaction design; product design; HCI/UX research	> 5 yrs	Miro; FigJam; Zoom Whiteboard	At least once a month
P4	HCI/UX research; data visualization	> 5 yrs	Miro; Google Jamboard; Zoom Whiteboard; Excalidraw; Lucidchart	At least once a week
P5	HCI/UX research	1–3 yrs	Miro; FigJam	At least once a week
P6	HCI/UX research	1–3 yrs	Miro; FigJam; Zoom Whiteboard	At least once a week
P7	HCI/UX research	3–5 yrs	Miro; FigJam; Google Jamboard; Zoom Whiteboard	At least once a month
P8*	HCI/UX research	1–3 yrs	FigJam; Zoom Whiteboard	At least once a week

Table 8: BLV participants in the user evaluation (Study 1). Six participants (B1–B6) also attended the BLV-sighted collaborative ideation sessions (Study 2). Ideation experience reports an approximate count of brainstorming sessions they joined in the last two years, irrespective of whether or not any digital whiteboards were used in the sessions.

ID	Self-Reported Disability	Experience with Digital Whiteboarding Tools	Ideation Experience	Occupation
B1	Legally blind; small residual vision in one eye	Only heard of it	1–5 times	Lead accessibility tester
B2	Blind; no usable vision	Only heard of it	>15 times	Accessibility analyst; tactile designer
B3	Totally blind; some light perception	Only heard of it	10–15 times	Assistant Director of disability support and assistive technology
B4	Completely blind; Microtia	Only heard of it	1–5 times	Vocational rehabilitation counselor
B5	Blind in one eye, can see a little bit; learning disability; auditory delay; Cerebral palsy	Only heard of it	>15 times	Accessibility analyst
B6	Retinopathy of Prematurity stage 5	Tried once (Google Jamboard)	>15 times	Library outreach manager; research associate
B7	Fully blind	Tried 6 times (FigJam, could not recall names of other tools)	10–15 times	Mobile accessibility engineer
B8	Totally blind	Tried 1-2 times (Google Jamboard)	1–5 times	Webmaster; accessibility tester
B9	Visually Impaired	Tried 1-2 times (Zoom Whiteboard)	>15 times	Assistive technology coordinator
B10	Leber's congenital amaurosis	Tried 3-5 times (Miro, Zoom Whiteboard)	6–10 times	Digital accessibility specialist
B11	Fully blind; minimal light perception	Tried several times (Miro, FigJam, Google Jamboard)	10–15 times	Web engineer
B12	Blind	Tried before but not within the last 2 years	>15 times	Accessibility architect
B13	Totally blind	Tried 1-2 times (Miro, FigJam)	>15 times	Designer

Table 9: Sighted participants attending the collaborative ideation with B1–B6 (Study 2). S2 also participated in the formative study (P8 in Table 7). Ideation experience reports an approximate count of brainstorming sessions they joined in the last two years.

ID	Relationship with BLV participant	Ideation experience	Whiteboarding experience	Experience with BLV people or assistive technologies
S1	N/A	> 15 times	Used many times	Familiar with assistive technologies BLV people use.
S2*	N/A	> 15 times	Used many times	No experience.
S3	N/A	> 15 times	Used many times	Interacted with BLV people in person.
S4	Family	About 6-10 times	Used Figma a couple times	Familiar with assistive technologies BLV people use; interacted with BLV people in person.
S5	N/A	> 15 times	Used many times	No experience.
S6	Friend	About 1-5 times	Never heard of it	Interacted with BLV people in person.

Table 10: Statements used for 5-point Likert-style rating scale (ranging from 1: strongly disagree to 5: strongly agree) and open-ended questions used in Study 1 (Section 5.2). The asterisk (*) denotes that the questions were only asked in the Idea11y condition because the baseline interface (Miro) did not support these actions at the time of this study.

Task Category	Question Type	Question
1: Reading board content and collaboration information	Likert rating statements	I could easily understand overall information about the board, such as the number of users, clusters, and colors.*
		I could easily understand what notes were on the board.
		I could easily find a particular note on the board.
		I could easily understand how notes were grouped on the board.
		I could read through all the notes quickly.
		I could easily find out the color of a note.
		I could easily find out who created what note.*
		I could easily find out which note a collaborator is currently working on.*
		The collaborator notifications were disruptive to my reading flow.*
	Open-ended questions	Could you share your thoughts on reading the board content using this interface?
		Are there any features that you particularly liked or did not like at all?
		Are there any ways these features could be improved or any new features might be added?
2: Manipulating board content	Likert rating statements	I could easily add a note.
		I could easily understand where the new note I added was located.
		I could easily move a note to where I wanted it to be.
		I could easily edit the text of a note.
		I could easily edit the color of a note.
		I could easily delete a note.
		It was easy to learn how to perform these actions on a note.
	Open-ended questions	Could you share your thoughts on adding, editing, moving, or deleting notes using this interface?
		Are there any features that you particularly liked or did not like at all?
		Are there any ways these features could be improved or any new features might be added?
	Comparing Idea11y and baseline	You have explored two different interfaces to read content and add, delete, edit or move notes on a digital whiteboard. Reflecting on your overall experience, which one of these two interfaces did you like better and why?
*3: Understanding voice coding	Likert rating statements	I could easily differentiate which notes were created by whom.
		I could easily differentiate which notes had what colors.
	Open-ended questions	Could you share your thoughts on exploring notes with different voices?
		Is there anything about this feature that you liked or did not like at all? Would you prefer different voices for colors or for creators? Why?
		Are there any ways that this feature could be improved or any new features might be added?
*4: Voting	Likert rating statements	I could easily know which ideas were preferred by others.
		I could easily vote on the ideas that I preferred.
		I found the voting overview useful.
	Open-ended questions	Could you share your thoughts on the voting features?
		Are there any features that you particularly liked or did not like at all?
		Are there any ways these features could be improved or any new features might be added?
	Final questions	Could you share your overall thoughts on Idea11y?
		Was there anything that you particularly liked about this tool or did not like at all?
		Do you think this tool might be useful for your work in any way? In what contexts and how might you use this tool?
		Are there any new features that you would like to have in a future version of this tool?