ChatGPT

Co-Thinking through Collaborative Drawing: Integrating Voice and Sketch in Shared Ideation Spaces

Collaborative Drawing and Co-Thinking: Cognitive Foundations

Collaborative sketching sessions are more than just visual note-taking – they create a shared cognitive space where multiple minds "think" together through drawing. Theories of **distributed cognition** suggest that when two or more people work on a shared drawing, they effectively form one distributed cognitive system, where ideas emerge from interactions among the individuals and the external drawing [1] [2]. In other words, the group's mind extends onto the paper or screen. Each pen stroke helps externalize thought in a tangible form, making it easier for collaborators to follow the evolution of each other's ideas [3]. This externalization is powerful for maintaining **common ground** – as collaborators sketch and gesture, they build shared references and understanding.

Embodied cognition further explains why "drawing together" boosts co-thinking. Physically sketching (using hand movements, gestures, and strokes) is not just motor output but an integral part of the thinking process [4]. Studies show that hand gestures play a *productive* role during joint drawing: people point to parts of a sketch, mimic motions, or outline shapes in the air to convey ideas [5]. These gestures, tightly coupled with the visual marks, help encode meaning and coordinate turn-taking (e.g. raising a hand or stylus to signal one wants to add something) [6]. Notably, the meaning of rough sketches often *unfolds over time* through conversation and action. A set of marks that might look cryptic in isolation can become clear when one considers the sequence and timing in which they were drawn and discussed [7]. This temporal aspect – the synchronized dance of drawing, gesturing, and talking – is key to "co-thinking." It's through the live **process** of sketching (not just the final diagram) that a group comes to a shared insight [8]. Researchers have observed that if this synchronous timing is disrupted (for example, by lag or lack of awareness), collaborative interpretation suffers [9]. All these findings underscore that collaborative drawing is a rich social-cognitive activity: by sketching together, teams literally **draw out** each other's thoughts, making abstract ideas concrete and collectively negotiable.

Sketches and Strokes as Scaffolds for Shared Thought

Freehand sketches provide a **scaffold for thinking** in ways that formal text or speech alone do not. In design studies, van der Lugt (2005) identified several unique functions of sketching in group idea generation: it supports a *reinterpretive cycle* (the sketch can trigger new insights each time someone revisits it), and it creates an external memory of ideas that everyone can look back to [10]. In practice, collaborators often find that *ambiguous* or rough drawings are especially valuable during brainstorming. Unlike polished visuals, rough strokes can be interpreted in multiple ways, inviting team members to imagine alternatives and build on each other's ideas [11] [12]. A squiggly line or half-formed shape might suggest different things to different people, sparking questions ("Is that a cloud or a thought bubble?") that lead to deeper discussion. This aligns with design thinking wisdom that *sketching spurs creativity*: the very indeterminacy of

a sketch prompts the brain to fill gaps and make new connections [11]. As one researcher put it, "when visually depicted, ideas are more able to inspire new ones" [12].

Moreover, the sketch itself becomes a **shared memory** for the group. Each stroke added to a common whiteboard is a persistent trace of the dialogue up to that point. This persistence helps teams "offload" cognitive load – they no longer have to hold every detail in mind because the sketch captures it externally [13]. Team members can *anchor* their conversations to parts of the drawing ("Let's refine this section over here…") and later refer back to earlier drawings to recall how an idea evolved [10]. Studies in educational settings similarly note that joint drawing can "activate a group mind" by creating shared narrative artifacts [14]. In essence, collaborative strokes knit individual thought threads into one canvas, making **co-thinking** visible. Best of all, sketching is a two-way street: it not only communicates ideas but also **shapes** them. As collaborators sketch, they often find themselves refining their own understanding ("drawing to find out what you think"). This reflective aspect of drawing together – where each new mark can prompt a clarification or a *"What if…?"* – helps groups converge on insights that none might have reached alone.

Designing Pen-Based Shared Ideation Spaces

Designing a digital whiteboard or sketch interface for collaboration means recreating the fluidity of pen on paper *plus* adding smart support for remote teamwork. Traditional whiteboards have long been prized in design teams because they provide a **"fluid and flexible medium"** for informal collaboration – you can jot, erase, circle, and connect ideas on a whim [15]. Digital pen-and-tablet interfaces aim to preserve this spontaneity while overcoming distance barriers. Research in human-computer interaction (HCI) has revealed several design considerations for such systems:

- **Capture natural gestures and spatial interactions:** In face-to-face collaboration, teammates rely heavily on gestures (pointing, encircling a drawing, miming motions) to complement the sketch [5]. A digital whiteboard should convey these gestures or their equivalents. Early systems like *VideoDraw* (1990) tackled this by merging video feeds of each collaborator's hand as they drew, ensuring that pointing and hand movements were seen alongside the digital ink [16]. Modern solutions use techniques like telepointers (an on-screen cursor or colored dot for each person's pen) or stylus position indicators to mimic the "I'm pointing here" effect. The goal is to maintain the tight **coupling of gesture and sketch** so that a remote participant's reference ("look at this curve *here*") is immediately clear to others [17]. Additionally, respecting spatial arrangement is important – for instance, if multiple people draw at once, the system should prevent confusion by showing each person's location or region of work. Empirical studies show that collaborators can indeed sketch simultaneously without chaos, so long as there are subtle cues to negotiate space and timing (much as people naturally avoid hand collisions on a physical whiteboard) [18]. Features like cursor avatars or colored pen trails can provide this awareness.

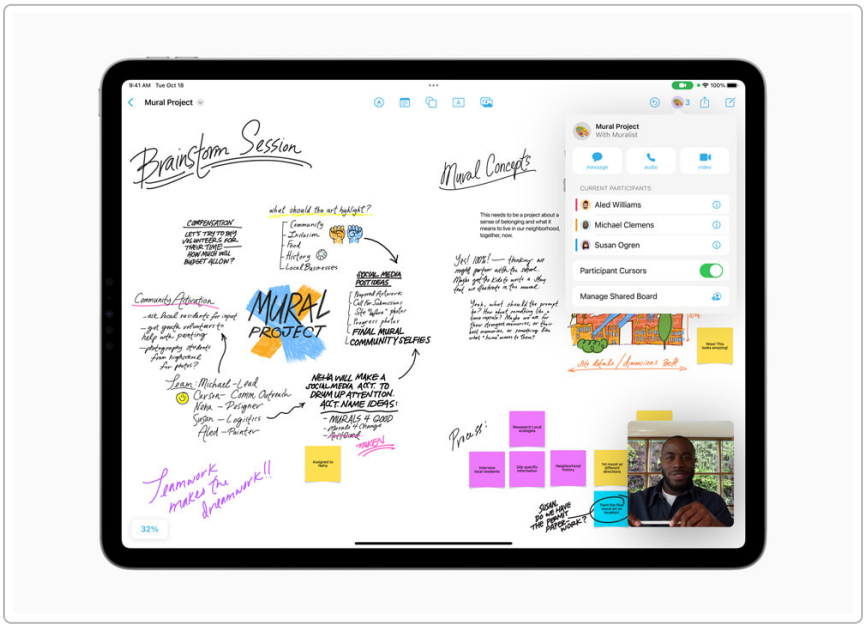
- **Support pen & stylus input for fidelity and feel:** For a sketching tool, the stylus (or finger, on touch devices) is king. A wealth of research supports that drawing with a pen is cognitively different and often more effective for ideation than using a mouse or typing [19] [20]. The tactile analog feel of a pen can engage users' motor memory and allow more expressive strokes. Thus, collaborative drawing systems typically prioritize inking capabilities: smooth digital ink that keeps up in real-time, pressure sensitivity for nuance, and minimal latency to feel "live." For example, many tablets like the iPad Pro offer a near-zero lag experience with Apple Pencil, which is crucial when multiple people are sketching together so that each stroke appears instantly to everyone. Likewise, **infinite canvas**

designs (where the board expands as you draw) are popular – they let teams sketch freely without worrying about running out of space or having to switch pages [21]. This replicates the experience of moving to a new section of a wall or adding another sheet of paper in a real workshop, keeping the creative flow going.

- **Real-time coordination and awareness:** A major challenge in remote collaboration is providing awareness of others' actions. Design studies have found that timing is everything: in conversation, we avoid speaking over each other, and similarly in drawing, people subconsciously time their contributions [22]. Digital whiteboards can assist this coordination by showing when someone is *actively* drawing (e.g. a name label or glowing cursor while a collaborator's pen is down). Some tools even show a faint preview of the stroke as it is being drawn, not just after it's completed, to give others a cue to pause and watch. Text or icon-based signals (like "Alice is editing…") can also help manage turn-taking. **Concurrency control** is usually loose in modern whiteboards – everyone can draw at once – but the interface can mitigate conflict. For instance, gentle visual collision avoidance (each user's ink appearing above their own pointer to avoid overlap confusion) or alerting users if they unknowingly try to draw on the exact same spot are design tricks to maintain harmony. In one study, a shared whiteboard used by student teams revealed that having a designated facilitator (or agreed roles) further reduced chaos, and groups naturally fell into patterns where one would draw while others observed or commented, then switch [23] [24]. A well-designed system thus leaves room for these human protocols while providing just enough UI feedback to keep everyone on the same page – literally and figuratively.

- **Ease-of-use and low overhead:** To truly amplify sketch-based thought, the interface itself must "disappear" in use. Users should be able to **grab a pen and just start drawing**, as naturally as they would on paper [25] [26]. Any extra steps – complicated menus, logins, or requiring special hardware – can disrupt the creative flow. HCI researchers behind the *PaperSketch* system emphasized an *intuitive interface* as a top requirement: their participants wanted to focus on the sketching, not the software [25]. This means sensible defaults (pen tool is primary, not buried in a submenu), simple gestures for common actions (e.g. a double-tap on a stylus to switch to eraser, as on Apple Pencil), and cross-device flexibility so collaborators can join from whatever device they have (tablet, laptop, or even an interactive large display). In the same vein, **minimal friction to share or save** is important – one-click to start a collaborative session or to export the board for later. The smoother these interactions, the more seamlessly teams can move from an idea in someone's head to a collective sketch on the canvas.

Integrating Voice and Visual: Multimodal Collaboration Tools



Apple's Freeform app integrates a FaceTime call directly into a shared whiteboard. Here, remote collaborators can sketch together on an infinite canvas while seeing and hearing each other, combining visual brainstorming with live voice/video communication.

Real-time voice communication complements collaborative drawing by providing immediacy and rich context – tone of voice, laughter, exclamations – that a sketch alone cannot convey. Modern collaboration platforms therefore strive to **integrate voice (and video) seamlessly into the sketching experience**, creating a multimodal ideation space. The screenshot above from Apple **Freeform** illustrates this approach: as two colleagues sketch on a shared board, they can talk via an embedded FaceTime video call, essentially recreating the feeling of standing around the same whiteboard [27] [28]. This convergence of voice and drawing helps remote collaborators maintain the "flow" of discussion without having to switch to a separate app or device for conversation. Apple's design philosophy was to bring *everything into one place* – with Freeform, users can invite others via iMessage and launch a FaceTime call from right inside the board, all with a tap [29] [30]. Fast cloud sync ensures that every stroke appears almost instantly for everyone, so when someone says "Take a look at this," the sketch updates in lockstep with their words [31].

Other industry tools echo this integration trend. **Figma**, a popular design collaboration tool, introduced built-in audio chat in 2021 so teammates could "*talk it out*" without leaving the design file [32]. The idea was to remove the friction of hopping on a separate call or meeting – instead, a team member can simply turn on Figma's audio and speak while all participants see the design or diagram in real time. Figma even added fun touches like **cursor chat** (users can type short transient messages attached to their mouse cursor) and virtual high-fives, aiming to recreate some of the spontaneity of in-person teamwork [32] [33]. As Figma's designers noted, working together often requires more than being in the "same file" – it requires easy ways to ask questions, clarify points, and celebrate little wins in the moment [34]. By embedding voice, they enabled *lightweight jam sessions*: teams can jump into a quick brainstorm with voice and sketch, without the formality of scheduling a separate video meeting [35]. Notably, they chose audio-only (without mandatory video) for many cases, since **video isn't always necessary** when everyone's focus is on a shared visual

board [36]. This reduces cognitive load (no need to perform for the camera) and bandwidth, while still preserving the critical verbal channel. In Figma's words, these features brought back *"magical moments"* like a spontaneous hallway conversation – except now the hallway is a digital canvas [33] [37].

Miro, another widely used online whiteboard, follows suit with integrated voice/video calls. Miro's board users can launch a video chat panel within the board, supporting up to 25 participants at once [38]. This is essentially a built-in mini-conference: team members can see and hear each other while co-drawing sticky notes, diagrams, or interface sketches. Miro's emphasis is similarly on keeping everything in one app – screen sharing, video, and even live cursor tracking happen together [39]. A key advantage Miro highlights is how this **real-time coupling** of voice and sketch "enables team discussions, decisions, and actions [to] happen simultaneously without additional software" [40]. In practical terms, that means a facilitator can drag in images or type notes on the board *as* the team discusses them, or participants can literally draw out an idea while explaining it aloud. By recording calls and even transcribing audio to sticky-note summaries on the board, some tools ensure nothing gets lost [41]. This integration can **amplify stroke-driven thought**: a sketch can be annotated verbally in the moment ("This arrow represents the data flow…"), and those spoken insights can later be retrieved from transcripts or captions, linking the ephemeral voice channel with the persistent visual channel.

It's worth noting that integrating voice isn't only the realm of software products – hardware and hybrid approaches are exploring it too. For instance, dedicated e-ink tablets like **reMarkable** (famous for their paper-like drawing feel) don't yet support multi-user drawing in real time, but they allow *screen sharing* of your drawing session over a call. A user can "broadcast" their reMarkable notebook via a live view on a computer, so colleagues on a Zoom or Teams call can watch the sketches unfold stroke by stroke [42]. This has been touted as a way to make remote meetings more interactive: rather than holding up a notepad to a webcam, a presenter can draw naturally on their reMarkable, and everyone sees the ink appear live on their screens [43]. It's a one-to-many model (one active drawer, multiple viewers) rather than a true multi-editor canvas, but it clearly addresses the same theme – combining voice conversation with the power of hand-drawn visuals. The enthusiasm for such features (as evidenced by user communities eagerly requesting real collaborative editing on e-ink devices [44]) underscores a general principle: people want to **talk and draw at the same time**, in an experience as close to an in-person whiteboard brainstorming as possible.

Research prototypes have even gone a step further by adding novel modalities to the voice+sketch mix. For example, a system called *EyeDraw* investigated sharing eye gaze information during remote collaborative drawing to complement voice communication. The idea is that if you know where your partner is looking on the canvas, you gain an "individual space for divergent thinking" without constantly interrupting each other [45]. Early findings suggest such shared gaze cues can **augment voice** by preventing confusion (e.g. both people can silently focus on different sub-parts of the sketch, then converge via speech when ready). While still experimental, it points to future interfaces where multiple channels – voice, ink, gaze, even hand poses – all work in concert to support collaborative ideation.

Key Design Principles for Voice+Sketch Collaboration

Designing an effective "iPad/reMarkable Pro Bridge" – essentially a hybrid voice-chat + sketch platform – involves weaving together insights from the above research and industry practices. Here we summarize some best practices and recurring design principles that emerge:

- **Low-friction communication:** Enable users to initiate voice chat or calls *within* the drawing app with minimal effort. Collaboration should be spontaneous – for example, Figma's audio chat can be started in one click, without switching to Zoom or sending calendar invites [46]. The easier it is to talk while drawing, the more naturally teams will engage in co-thinking dialogue.

- **Unified space for voice and visuals:** Wherever possible, avoid splitting attention between separate windows or devices for communication and drawing. Embedding voice/video in the canvas (as Freeform and Miro do) keeps everyone focused on the shared content [40] [27]. A single integrated space reinforces context – when someone says "this part," they can simultaneously circle or highlight "this part" on the board for all to see.

- **Real-time presence and gestural cues:** Provide awareness of each collaborator's actions and focus. For instance, show live cursors or a colored dot for each user's pen position, and consider displaying names or avatars by recent strokes. This preserves the gestural back-and-forth of an in-person session [5]. If a collaborator is gesturing or looking at a specific region, a digital equivalent (like a halo where their pointer dwells, or even shared gaze tracking in advanced systems) can maintain that referential context. The aim is to **"convey hand gestures among collaborators, and maintain their relationship to the drawing"** as was deemed crucial in early studies [17].

- **Support simultaneous input with coordination:** Let multiple people draw at once, but design the interface to help them avoid stepping on each other's toes. Techniques include distinct stroke colors per person, temporary "drawing in progress" indicators, or dividing the canvas into zones if needed. Social protocols often emerge naturally, but the system should handle overlaps gracefully (no sudden steals of control or loss of strokes). Research shows people can negotiate shared space in time and avoid conflicts if the system provides a "familiar sense" of where others are working [18]. Think of it as giving users peripheral vision in the digital space.

- **Infinite canvas and spatial organization:** Encourage brainstorming flow by using an expansive or zoomable canvas that grows with the content [21]. This allows groups to branch off into sub-areas for different ideas (and later draw connections between them) without feeling constrained. Spatial layout can be a cognitive tool: teams might use one corner for "idea A" and another for "idea B," which keeps discussions organized. The system can offer easy navigation (pinch-zoom, minimap) so voice conversations like "Let's all look at the top-right sketch" are easy to follow.

- **Ambiguity-friendly drawing tools:** Emphasize freehand sketching and do not force premature polish. Rough strokes, doodles, and handwritten text should be first-class citizens in the interface. This is because ambiguous shapes often spark creativity and invite input [11]. Features like shape auto-correction or perfect alignment can be useful for final outputs but may be counterproductive during early ideation. A best practice is to let users toggle such aids on *only if* they want them. In essence, **preserve the sketchy nature** of sketches – it's okay if the lines are squiggly. They are working **cognitive tools**, not presentation graphics, during co-thinking sessions.

- **External memory and persistence:** Treat the shared board as the group's external memory. Provide options to save snapshots or versions of the board, so teams can revisit the evolution of ideas later. Some systems integrate version history or "replay" of sketches over time. At minimum, after a session ends, the drawn artifacts should persist for asynchronous reflection. This supports the principle that sketches enhance "access to earlier ideas" [10] . For example, a team might return to a collaborative sketch in the next meeting to pick up where they left off. Persisting content also means late joiners can catch up by reviewing what was drawn while they were away (possibly alongside an audio transcript or summary if available).

- **Multi-modal accessibility:** Make the collaboration inclusive by accommodating different communication needs. If voice is integrated, adding live captioning or transcription can help non-native speakers or anyone who missed a comment [47] . (Figma, for instance, rolled out live captions so that everyone "in the file" can follow the conversation [48] .) Similarly, allow mixing modes – e.g. one person might prefer to type notes or use an on-screen chat, which should appear contextually on the board, while others speak. A robust system lets people contribute in the mode they're most comfortable, all feeding into the shared space.

- **Seamless integration with workflows:** Finally, a principle from industry is to meet users where they are. The collaborative sketch tool should integrate with common workflows – for instance, allow exporting the board to PDF, or integrating with project management tools, or easily sharing via messaging apps. Apple's Freeform ties in with the iOS ecosystem (boards stored in iCloud and shareable via iMessage) so that starting a collaboration is as simple as sending a link [29] . Miro integrates with calendar invites and Slack. These touches ensure the brilliant ideas sketched out don't live in a silo – they can be circulated, scheduled, and further developed in other contexts. For a hybrid physical-digital device (like the conceptual iPad/reMarkable Bridge), this might also mean syncing ink notes to cloud notebooks or allowing a reMarkable user to contribute to a board that an iPad user is also drawing on. In short, **interoperability** and ease of sharing are key: the value of a co-thinking space multiplies when its output can travel and be built upon.

In summary, the convergence of voice communication with collaborative sketching holds great promise for amplifying team creativity. Scientific literature and practical trials alike affirm that when people draw together while talking, they leverage both imagery and language to scaffold each other's thoughts in ways neither modality could achieve alone. A well-designed "drawing together" platform is one that feels as natural as grabbing markers in a meeting room, yet as powerful as a digital network – supporting rich pen input, instant sharing, and conversation all at once. By grounding its design in human cognitive principles (embodiment, distributed cognition) and proven HCI patterns (real-time feedback, low latency, flexibility), an **"iPad/reMarkable Pro Bridge"** could truly become a *shared ideation space* that catalyzes co-thinking. It would allow teams to sketch, gesticulate, chat, debate, and iterate – collectively making sense of problems with strokes and words in tandem. As the research shows, this multimodal dance of minds and markers can lead to deeper understanding and more creative solutions, ultimately making remote collaboration feel a lot more like the best in-person brainstorming sessions – or maybe even better, once augmented by the right technology.

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