Bridging Analog and Digital: Exploring the Present and Future of Digital Pens in Supporting Planning at Work

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Abstract

Task planning—deciding which tasks to complete and when—is essential for productivity and well-being at work. However, digital planning tools often struggle to fully meet the diverse needs of workers, prompting individuals to revert to analog methods like pen-and-paper for their simplicity and flexibility. This study explores how digital pens might bridge analog and digital practices to better support task planning. In Phase 1, a semi-structured survey with 74 participants revealed that while digital pens offer cognitive and creative benefits for planning, their potential is constrained by insufficient integration, customization, and conversion features. In Phase 2, a scenario-based design activity using the *PenPlan* prototype refined these insights to suggest concrete design priorities such as dynamic templates, targeted smart suggestions, and AI-powered search. Our findings suggest that digital pen-supported planning should move beyond replicating analog methods to offer smarter and more adaptive support for structuring, decorating and retrieving plans.

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CCS Concepts

• **Human-centered computing** → **Empirical studies in interaction design**; **Interaction devices**.

Keywords

Task Planning, Digital Pens, Time Management, To-Do List, Calendar

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1 Introduction

Task planning is an essential activity that underpins both productivity and well-being at work [14]. It involves identifying tasks, prioritizing them, and allocating time effectively, a process that helps ensure that workers, especially in knowledge sectors, manage their goals and deadlines [22]. However, despite its importance, planning remains challenging to support with digital tools. While digital solutions offer advantages such as automated reminders, calendar integration, and task sharing, many users continue to gravitate toward analog tools, particularly pen and paper [4, 16].

This preference is often driven by the simplicity, flexibility, and tactile engagement that analog methods provide, even as users express interest in the advanced functionality of digital systems [17].

Digital pens, often referred to as styluses, offer a hybrid solution that combines the intuitive and flexible nature of handwriting with the computational power of digital tools. These devices enable users to write or sketch on a screen while accessing digital features like searchability and collaboration through compatible applications. For instance, a digital pen, when used with mainstream productivity apps like Google Keep, allows users to create handwritten notes and synchronize them across devices. More specialized planner apps, such as Ajournal and NoteShelf 3, cater to the needs of digital pen users, offering functionalities such as digital planning templates. With the global digital pen market projected to grow from USD 2.93 billion in 2024 to USD 8.90 billion by 2033 [1], the development of new tools will likely accelerate. This highlights the increasing importance of understanding how to design these tools to effectively address user needs.

While some evidence suggests that digital pens are used in task planning [34], much of the existing research on planning practices has focused primarily on typing-based systems [5, 8, 11, 16, 22]. Digital pens, given their versatility, offer opportunities to support planning tasks such as jotting down to-do lists, prioritizing activities, and annotating schedules. However, despite the extensive investigations into general planning practices to inform tool design, there is limited user research on envisioning future digital pen-supported planning systems. Currently, digital planners often replicate the functionality of traditional paper diaries and calendars by providing digital templates, which, while useful, may fail to fully exploit the unique affordances of digital pens. This raises critical research questions: *What are the strengths and limitations of digital pens in supporting task planning, and how can digital pen-supported planning tools go beyond mimicking analog tools to deliver distinctive value?*

To address these questions, we conducted the first in-depth investigation into the use of digital pens for planning and contribute a set of design priorities for future digital pen planning tools. In Phase 1, we conducted a semi-structured survey with 74 digital pen users to examine preferences, barriers, and opportunities for innovation in digital pen-based planning. The findings indicate that while more than half of participants use digital pens for planning due to cognitive and creative benefits, their potential remains underutilized due to insufficient functionalities of note-taking tools. To address these limitations, future tools should prioritize three key areas: integration, customization, and conversion. Building on these insights, in Phase 2, we conducted a scenario-based design activity using a low-fidelity prototype, Planly, as a boundary object to elicit user reflections and gather feedback on how digital pens could be better integrated into planning practices. This two-phased approach demonstrates that while users value the flexibility and visual engagement of digital pen planning, existing tools require further development to better support the structuring, retrieval, and integration of handwritten plans. We propose concrete, novel improvements, such as dynamic templates, targeted smart suggestions, and AI-powered search, to improve the usability and effectiveness of digital pen planning.

2 Related Work

This paper draws on interdisciplinary research related to task planning, spanning human-computer interaction (HCI) and cognitive psychology. We explore how digital and analog tools are used for planning, the cognitive and functional benefits of handwriting, and the role of digital pens as a middle ground.

2.1 Use of digital and analogue tools for task planning

Task planning is defined as identifying tasks, recording them, prioritizing them, and allocating time effectively to complete them [22]. Users frequently combine digital and analog tools for planning, adapting their methods based on task type and personal preferences. Bellotti et al. [8] found that individuals use an average of 11.25 tools for managing tasks, while Hu et al. [18] reported an average of 9, spanning from specialized software, email, and calendar to handwritten notes and index cards. Haraty et al. [16] showed that users often have a preference for blending in general and custom planning tools, like Excel spreadsheets, paper and calendars.

The persistence of analog tools like pen and paper is particularly evident across studies of writing and reading work preferences [2, 26, 35]. This preference is also evident in studies on planning practices. For example, in an interview study with 26 IBM employees, Muller et al. [24] explored the design of digital request management systems—tools for tracking, delegating, and following up on work-related requests—aiming to improve upon traditional paper-based methods. They argued that digital solutions could *beat paper* in request management by enabling automation, collaboration, and better tracking of commitments. However, the study also acknowledged that paper endures because of its simplicity, intuitive nature, and alignment with users' natural work practices. In addition, Kamsin et al. [19] observed that digital planning tools often *fall apart* under high-pressure scenarios in academic work, where analog methods like jotting notes on paper remain reliable and manageable. Similarly, Ahmetoglu et al. [4] found that during the COVID-19 lockdown, many academics returned to paper-based planning to alleviate screen fatigue and engage more intuitively with their tasks.

Wiese and Lund [40] observed that participants using their low-structure, typing-based planning tool often supplemented or reverted to analogue tools for tasks requiring greater freedom and adaptability. The structured nature of the digital tool's interface, while useful for some tasks, was seen as restrictive for planning processes that required flexibility, leading participants to favor pen and paper for those scenarios. Bernstein's research [10] on *information scraps* also highlights the preference for paper methods, such as sticky notes, which are valued for their immediacy and informality.

To support task planning meaningfully, tools must fit naturally with existing planning practices. Blandford and Green [11] argued for tools that support continuity by bridging analog and digital systems, such as enabling handwritten notes to be digitized or facilitating the simultaneous use of physical and digital calendars. Such tools could cater for user preferences and build on familiar practices. However, research since has often overlooked how these hybrid approaches that sit between analogue and digital can be integrated into the ecosystems of planning tools.

2.2 Cognitive benefits of analogue and digital handwriting compared to typing-based systems

The previous section highlights that people use a mix of planning tools, yet handwriting remains a persistent practice. One reason for this could be that handwriting offers unique advantages over typing-based methods. Research widely recognizes the cognitive benefits of handwriting in both analog and digital contexts. It is valued for its flexibility, simplicity, and tactile engagement, fostering a more intuitive interaction with content compared to typing-based systems. The physical act of writing activates multiple sensory pathways—kinesthetic, tactile, and visual—making it particularly effective for tasks that require cognitive effort [27].

Research has demonstrated that handwriting supports cognitive processes relevant to planning, including iterative refinement, problem-solving, and reflective thinking. For example, Plimmer and Apperley [30] showed that handwritten input facilitated incremental modifications and spontaneous restructuring in Freeform, a sketch-based UI design tool. Users made more frequent and precise revisions compared to structured, widget-based design tools. Similarly, their later study on annotation tools found that handwritten annotations provided greater flexibility for adjusting and organizing content than text-based systems [31].

Handwriting has also been linked to cognitive engagement and reflective thinking, which are central to planning [14, 23]. Research on hybrid analog-digital systems by Arnera et al. [6] found that such systems supported reflective practices by allowing users to shift between handwritten and digital representations. This flexibility enabled deeper engagement with tasks compared to either analog or digital tools alone. Cohen and Oviatt [28] further demonstrated that handwriting, particularly with digital pens, fosters structured problem-solving due to its slower, more deliberate nature.

Given these cognitive benefits, researchers have explored ways to incorporate handwriting into digital practices (though not specifically focused on task planning). Some hybrid systems, such as those studied by Steimle et al. [37, 38], integrate handwriting with digital features, allowing annotations to be tagged, linked, or reorganized. These approaches aim to preserve the intuitive qualities of handwriting while improving organization and retrieval. However, much of this research comes from information management streams of HCI and focuses on paper-based input systems that transfer handwritten notes into a digital format. The extent to which digital pens, as standalone tools, can support planning-related tasks remains underexplored.

2.3 Opportunities for digital pen-supported planning systems

Digital pens allow users to write, draw, and annotate directly on digital surfaces, offering the flexibility of traditional pen-and-paper methods while incorporating digital functionalities such as saving, organizing, and sharing content. Digital pens have been proposed as a means of integrating information and communication technologies into contexts where traditional paper-based practices remain dominant, such as formal education, collaborative knowledge work, and clinical therapy. For example, digital pens have been used to help students with disabilities by supporting note-taking [9], and to create interfaces that aid speech-language therapy [29].

A large body of research on digital pens has focused on their role in note-taking. Digital pens are widely adopted for sketchnoting, brainstorming, annotating documents, and creative tasks. Tools such as the Microsoft Surface Pen and Apple Pencil, which integrate with applications like OneNote and Procreate, enable users to perform these tasks in work and creative contexts. For example, Riche et al. [33] demonstrated that digital pens facilitate brainstorming by allowing users to quickly visualize ideas while maintaining the intuitive qualities of analog tools. Similarly, Zheng et al. [42] found that digital pens support sketchnoting via improving personal expression, customization, and quick re-organization.

Despite their versatility for taking notes, digital pens have received little research attention in the context of task planning. While studies have noted that digital pens are used for planning, the focus of these studies has not *specifically* been on supporting planning. For example, in [33], the authors examined the affordances and activities associated with digital pens through a diary study and a large-scale survey. The diary entries revealed that participants frequently employed digital pens for tasks that involved annotation, freeform note-taking, and to-dos. Similarly, Romat et al. [34] investigated digital ink as a medium for creative journaling and personalization, observing that users employed digital pens for to-do lists and calendar entries within note-taking applications.

Therefore, studies suggest that digital pens are already used for planning in some capacity. However, current digital pen-supported applications often lack dedicated planning features, such as the ones that are found in dedicated typing-based planning apps [3]. Instead, digital planners for digital pens (e.g Ajournal) focus on digitized templates that are commonly found in paper diaries. While using a digital pen is known to encourage ideation, further research is needed to explore how these benefits can be effectively leveraged for planning tasks. Additionally, examining how digital pens fit into the broader ecosystem of planning tools—including analog methods, typing-based applications, and collaborative platforms—could provide valuable insights into their role in task planning. Therefore, the research questions addressed in this study are: what are the strengths and limitations of digital pens in supporting task planning, and how can digital pen-supported planning tools go beyond mimicking analog tools to deliver distinctive value?

3 Phase 1: A User Study to Explore Current and Imagined Practices

In Phase 1, we conducted a semi-structured survey with 74 digital pen users to examine preferences, barriers, and opportunities for innovation in digital pen-based planning.

4 Phase 1: Method

4.1 Participants and recruitment

Participants in this study were recruited via mailing lists, social media and word of mouth. To be eligible to take part, participants had to be: (1) healthy (absence of mental health conditions) (2) aged over 18 years old, (3) have experience using a digital pen and (4) regularly manage and plan tasks by using pen-and-paper tools and,

Survey Questions Version 1 (*N* = 36)

- Background questions
- Describe your experience of using a digital pen.
- What would make a digital pen more useful to you?
- What are your favourite tool/s for creating to-do lists?
- Do you currently have more than one to-do list? Why?
- Have you ever used a digital pen for creating a to-do list?
- If yes, what went well and what didn't? If no, what would encourage you to use a digital pen for creating your to-do lists?
- Are there any tasks or activities where you believe using a digital pen does or could help you break tasks into smaller chunks?
- Do others influence how you manage tasks (e.g., shared to-do lists with colleagues or family, task delegation)? If yes, what tools do you use, and how well do they work? If no, what tools would you prefer for coordination?

Survey Questions Version 2 (*N* = 38)

- Background questions
- Describe your experience of using a digital pen.
- What would make a digital pen more useful to you?
- Describe your planning process, including the tools you use.
- Describe your experience with pen-and-paper and/or digital methods for scheduling tasks.
- What are the pros and cons of online calendars versus pen-and-paper ones?
- Have you used a digital pen for planning tasks (e.g., bullet journaling or digital planners)? If yes, what worked well or didn't? If no, what would encourage you to try?
- Would you be open to using a digital pen as part of managing your online calendar?
- Share your thoughts, concerns, or suggestions about using a digital pen to manage your digital calendar and schedule.

Figure 1: Description of survey questions

or, digital tools. Each participant who completed the study was compensated with a £30 Amazon voucher for their participation.

A total of 163 survey responses were collected. However, an initial review revealed that many responses appeared to have been generated using Generative AI tools, as they included irrelevant answers or generic placeholder text. To identify such cases, the authors independently assessed each response for its likelihood of being generated by a language model and reached consensus through discussions. Based on this process, 89 responses were excluded, leaving 74 valid responses in the dataset.

Forty-two participants identified as female and 32 identified as male. The average age of participants was 28.5 years (SD = 8.2 years, range = 18-58 years). Participants primarily came from the United Kingdom (N = 63), followed by the United States (N = 6). Additional individual participants represented the Netherlands, Venezuela, Hong Kong, Nigeria, and Denmark. Twenty-seven participants were in work, 28 were studying, 16 combined work and study and 3 were unemployed. For those in employment, the most commonly represented field of work was academia which accounted for 44% of participants. However, participants from a range of sectors were included in the sample, including sales, user experience and hospitality.

4.2 Ethical approval

The study was approved by the UCL Research Ethics Committee. Informed consent was obtained from the participants before conducting the survey. Data were collected, stored and processed in compliance with the Data Protection Act 2018 and General Data Protection Regulation.

4.3 Materials

Data was collected via an online survey containing open-ended questions, designed to explore different aspects of task planning focusing both on existing practices and suggestions for new avenues for potential uses of digital pens. Two versions of the survey were created, each beginning with shared background questions about participants' demographic and occupational information, as well as their experience with digital pens (see Figure 1). Participants reported the devices and tools they use for planning in the background section of the survey. They could select more than one option. Then, the first version included questions focused on identifying tasks and prioritizing them, with an emphasis on to-do list use. The second version addressed allocating time to tasks, with questions about how participants use calendars. While the two versions slightly differed in their focus, they were similar in structure and aimed to provide complementary insights into the research question. To ensure detailed responses, participants were required to provide a minimum of 200 characters for each open-ended question.

4.4 Procedure

The data was collected using Qualtrics. The survey was administrated in four recruitment waves between May and July 2023. Participants responded to the study advertisement by completing an initial sign-up form. This form was used to verify that they met the eligibility criteria for the study, including that they had experience of using a digital pen. Participants could take part in only one of the versions of the survey. Provided they met the criteria, participants were sent a link to the Qualtrics form containing the survey. Participants could complete the form at their own pace and save their answers to return to later if they wished. After the end of the survey, 26 participants chosen at random were contacted via email and asked to provide a screenshot of their usual digital pen practices for planning to enrich the survey data with illustrative examples.

4.5 Data analysis

The data collected was pooled together prior to analysis using (bottom- up) thematic analysis [12, 15]. The data from both versions of the survey was analysed together by three researchers.

This process facilitated contextualising the participant's responses within their larger perceptions around related constructs like planning behaviours, use of planning tools, and patterns of work. The initial round of coding was done by hand. Each participant's response was read several times, and initial codes were written on post-it notes. This process was repeated twice for each participant, with codes being modified, added, or deleted iteratively. The refined codebook was then digitized in NVivo 14 Plus, facilitating comparisons both within and across participants' responses. The researchers frequently held meetings to discuss the codebook, ensuring that the codes accurately represented the data. Through this process, similar and related codes were grouped into broader categories, which were then refined into overarching themes.

5 Phase 1: Findings

As it can be seen in Figure 2, participants most commonly used physical pens (N = 58) for planning, followed by phone apps (N = 44) and digital pens (N = 41). Other frequently mentioned tools included physical pencils (N = 40), highlighters (N = 34), and computer applications (N = 33). Paper notepads (N = 31), iPad apps (N = 25), digital calendars (N = 18) and paper diaries (N = 17) were also moderately used. Less commonly used tools included word processors (N = 11), paper-style tablets (N = 7) and paper calendars (N = 5). On average, participants used 4.9 main task planning tools.

Figure 3 illustrates the planning practices that participants engaged in when using digital pens. We selected examples that illustrated different user practices to demonstrate the variability of use. Participants used digital calendars alongside their planners to structure daily plans (a). Note-taking applications were employed for visual planning, such as creating mind maps, which were often combined with typed to-do lists (b). Participants utilized the search function within note-taking apps to locate specific tasks while using a digital planner (c). Additionally, tools like Microsoft Whiteboard were used to support bullet-journaling (d).

The thematic analysis identified four main themes: Preference for Paper Amid Evolving Planning Needs, Deeper Engagement with Planning Through a Digital Pen, Usability Limitations Preventing Use, and A Need for Tools That Adapt to User Practices. These themes reflect participants' varying approaches to task planning, the perceived benefits and limitations of digital pens, and the need for tools that align more effectively with user practices. Each theme, comprising ten sub-themes, is described in detail below. Participants' IDs are coded as: first or second version of the survey (V-), followed by the recruitment round, with two for each version (R-) and the number of participants within that recruitment wave (P-).

5.1 Theme 1: Preference for Paper Amid Evolving Planning Needs

Participants expressed a strong preference for pen-and-paper over digital alternatives. However, practical challenges often necessitated abandoning or supplementing it with digital tools. This theme examines why participants preferred paper, the limitations that often led to a shift, how some combined both systems to navigate evolving needs and their views about using a digital pen for work.

5.1.1 Consistent Use of Pen-and-Paper. For many participants, pen-and-paper remained their default planning tool. The physical act of writing and crossing off tasks provided a sense of control and accomplishment: *I think it works for me because I am very visual. I can see my tasks spread out in front of me on a sheet of paper and easily make sure that everything is getting done* (V1R1P12). Paper was particularly valued in moments of overwhelm, where its simplicity allowed participants to reorganize their thoughts: *Whenever I feel overwhelmed with my recent work, I reach for a pen and paper and start jotting down all my tasks in a list. The flexibility of paper allows me to easily arrange and reorganize the items as needed* (V2R2P1). The act of crossing off tasks had an emotional significance: *Every time I cross off the task that I plan in the paper (because I have completed it), it gives me a sense of accomplishment and gives me confidence to finish the tasks next day* (V1R2P10).

5.1.2 Leaving Paper Due to Practical Drawbacks. Despite their attachment to paper, many participants faced challenges that made continued use difficult. Common barriers included losing important notes, difficulty maintaining organization, and the need for features better supported by digital tools: *My preference is for pen and paper, but this has resulted in scraps of paper, post-it notes, and larger to-do lists floating around and getting lost. I moved to digital planning as it's (slightly) harder to lose and means I can keep track of all tasks in one place* (V1R1P1). Digital tools offered critical advantages, such as synchronization, portability, and ease of updates, making them more practical for collaborative or long-term planning: *I used to use pens and paper a long time ago. I filled in my tasks for the week on paper, but I only use digital planning now because I will never lose my schedule, and it's easier to change things* (V1R2P9). The demands of work often drove this shift, as digital platforms supported collaboration and coordination in ways that paper could not: *I use a calendar to sync my schedule with my colleagues. Our company uses Asana and Shortcut for project management [...] the calendar works well for quickly scheduling meetings with others* (V1R1P11).

5.1.3 Combining Paper and Digital. Many participants found value in combining pen-and-paper with digital tools, allowing them to preserve the benefits of both. Paper was often used for creative, individual, or unstructured tasks, while digital tools handled complex, collaborative, or long-term planning. For example, one participant described relying on paper for its simplicity while using digital tools to track tasks across devices: *Nowadays I mainly use digital planning tools. First of all, you don't really lose your digital devices (while I forget where my paper notepad is). Second of all, it backs up and syncs to all devices. Third, it's easier to carry around* (V1R2P8). The decision to combine systems often depended on the task's context and complexity: *Indeed, my planning methods can vary depending on the context, even though I predominantly rely on my intuition for around 80% of scenarios. For the remaining 20%, the choice of planning medium often depends on the nature of the task and the expectations associated with it* (V2R1P1). Participants who used hybrid approaches suggested that neither system alone could fully meet their diverse planning needs. As V1R1P5 explained: *Online calendars are accessible, shareable, and customizable but need an internet connection and can be distracting. Pen-and-paper calendars are tactile and offline-friendly but lack shareability and customization.*

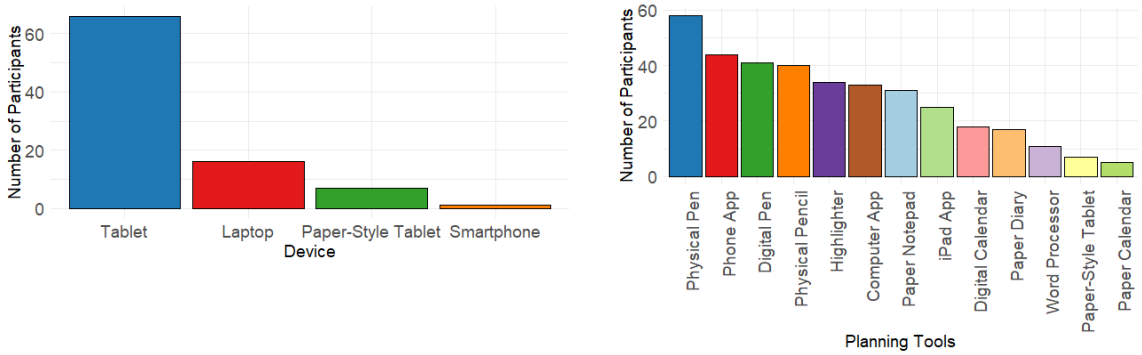


Figure 2: Left: Devices used with digital pens by participants. Right: Main planning tools used by participants.

5.1.4 Diverging Opinions About Digital Pens. Some participants noted that digital pens lacked the same feel of a real pen and experienced difficulties using it in the same way: *The main issue was that the digital pen did not feel like a real pen. My handwriting looked different digitally, and I couldn't achieve the same control as with my thin physical pen (Pilot G-Tec 0.4)* (V1R1P3). For others, one of the main barriers to using a digital pen for planning was *the glassy feel* of writing on a tablet: *I am very happy with the look and feel of my Apple Pencil or Logitech Crayon, but not so much with the glassy feel of writing on a tablet* (V1R1P2). However, a similar amount of responses noted that digital pens were easy to use and matched the feeling of a real pen: *The sensitivity is great and I've never had any issues with the screen getting confused between my hand resting on it while holding the pencil to write* (V2R1P1). Participants also noted that using a digital pen was easy to learn: *It was easy to learn to use it for the purpose I use it for: note-taking, marking up papers, and drawing* (V2R1P2).

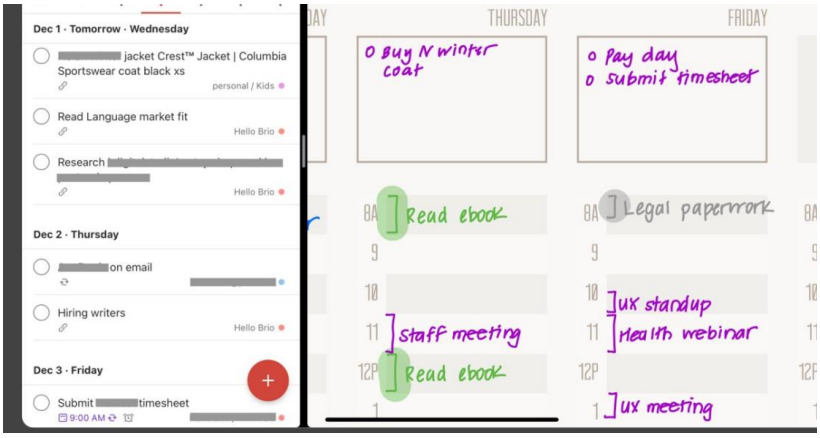
5.2 Theme 2: Deeper Engagement with Planning Through a Digital Pen

Participants described ways in which digital pens improved their engagement with planning tasks. The subthemes below outline how digital pens supported cognitive processes and facilitated aesthetic and creative approaches to organizing and presenting plans.

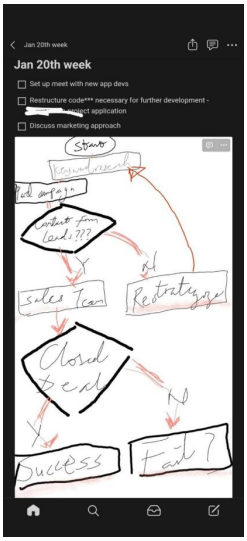
5.2.1 Cognitive Benefits. Participants shared that handwriting and drawing plans with a digital pen improved their cognitive processes, such as remembering what task they need to do: *The digital pen works well for me when planning my week because it helps me concentrate and think carefully through handwriting, and also help me have a better memory to keep a rough idea of what I have to do for each day* (V2R2P11). Handwriting and drawing facilitated better processing and understanding of information. The tactile nature of writing helped retain details more effectively than typing: *Writing by hand helps me process and remember information better* (V2R2P2). A participant shared that drawing a flow diagram with a digital pen helped them think through complex projects, breaking them down into parts and improving their overall planning: *[The use of a digital pen] helps think through a big picture story that can be broken down into meaningful sub-components to make sense. It'll also help me avoid making circular arguments* (V2R1P10). Using a digital pen for complex tasks, such as trip planning, made it easier to modify the task: *I used a digital pen to plan a trip itinerary, including bullet journaling, diagrams, and costs. It worked well because I could modify it repeatedly without changing the overall framework, and using different colors for data like tours and stays made it easy to understand* (V1R2P3). Participants also emphasized how digital pens helped them visually organize plans: *Digital pen would be helpful for activities like brainstorming, sketching ideas, and creating visual diagrams. Having features like unlimited virtual pages and some sort of stress-free editing would be useful* (V2R1P10).

5.2.2 Aesthetics and Creativity. Participants shared that it was important to them to make their plans visually appealing and felt that digital pens provided a means to increase how aesthetically pleasing their plans were: *Aesthetics is attention-worthy when it comes to hand-writing a to-do list, [we] want their plan to have a pleasant and concise layout* (V2R1P14). Using a digital pen made planning more creative and interactive, and added an extra layer of engagement with plans: *[Digital pens] could increase the creativity and fun of planning activity. This creates additional experience other than planning itself* (V1R2P10). Participants emphasized the importance of balancing creativity with the practicality of a tidy, organized list: *But of course, the application should be able to automatically tidy up the to-do list because sometimes handwriting would be a little messy. Finding the balance between the convenient features of digital applications and the creative experience through digital pen is important* (V2R2P23).

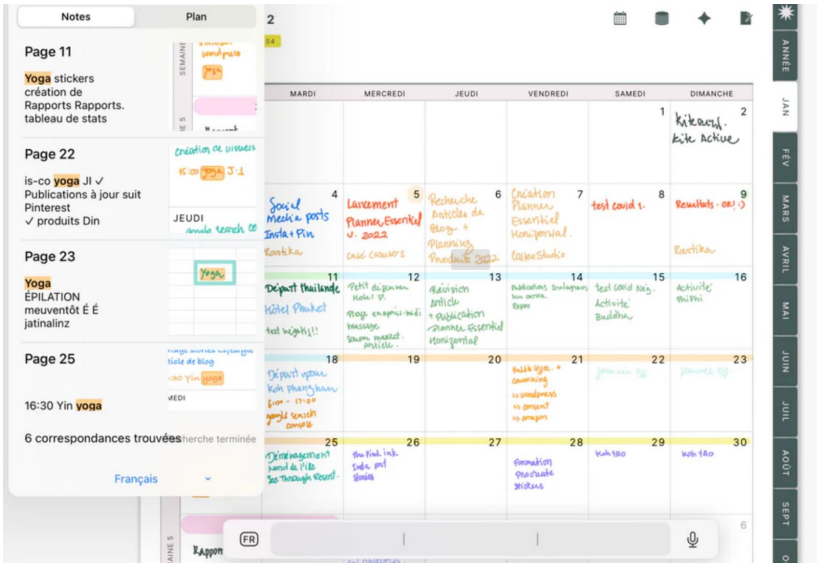
Participants mentioned how they actively sought ways to improve the visual aspect of their planning: *I even bought Goodnote templates so I can make it more aesthetically pleasing* (V2R2P8) Another participant found that digital pens allowed them to incorporate various elements into their plans, making the process more creative: *I find that digital pens make it easy to be creative with my planning, and I like that I can easily add images, notes, and other content to my planner* (V2R1P5) Participants also saw value in adding visual aids such as drawings or diagrams: *I could see that being able to add visual aids such as little drawings or diagrams to aid*



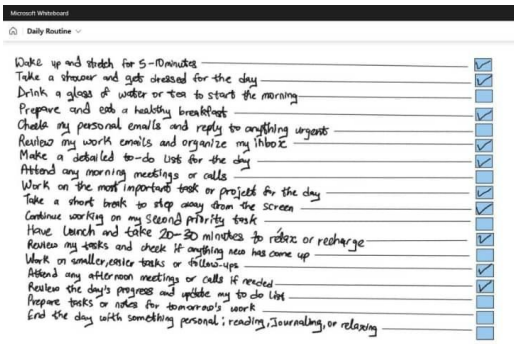
(a) Use of a digital calendar and a digital planner side-by-side on a tablet.



(b) Use of a phone notes app for typing in tasks and a mind-map via digital pen related to one of the tasks.



(c) Use of a digital planner and an example of searching phrases written via digital pen in notes.



(d) Use of Microsoft Whiteboard for tasks.

Figure 3: Four illustrative examples of participants' planning practices via digital pens showing different uses of digital apps for planning activities.

with personal tasks might be appealing to me because of the visual elements (V1R1P6). Participants also appreciated the ability to switch between different brush sizes and colors, which enhanced creativity and made planning more engaging: *Switching between different brush sizes and colors enhances creativity and helps in conveying ideas visually* (V1R2P13).

5.3 Theme 3: Usability Limitations Preventing Use

Participants reported several challenges in using digital pens for planning, related to limitations in apps' functionalities and insufficient knowledge about how to leverage the pen's capabilities for planning.

5.3.1 Insufficient App Functionality. Participants frequently mentioned the lack of suitable apps for planning with a digital pen. Many apps lacked essential features like collapsible lists, reminders, and task linking. One participant shared: *I have not yet discovered a digital-pen-friendly app that is designed for to-dos. Features available in standard to-do apps [...] are not possible in existing apps* (V2R2P7). Another participant noted: *Neither the pen nor the apps that it works with would give me any advantage over a mouse and keyboard, paper and pencil, or phone and thumbs* (V2R1P2).

Some participants tried digital planners or bullet journaling apps but struggled to adapt: *I've tried a few different digital planners, but none were as easy to use as my pen and paper. I've never been able to get used to the idea of having a computerized calendar that I can't draw on!* (V1R1P18). Others adopted apps like Apple Notes and GoodNotes out of convenience: *The Apple Notes app was already downloaded, and GoodNotes was the first one that appeared in the Apple Store when I looked for Notes apps with Apple Pencil* (V2R1P7). Additionally, some participants found digital pens less effective for shared planning. One participant explained: *A digital pen and iPad is useful for personal organization, but [...] my to-do lists need to be clearly understandable for my colleagues. My daily lists tend to be somewhat rough, and I don't find them particularly suitable for sharing* (V2R2P2). However, others expressed a need for sharing their plans done via digital pens, for example, by converting them to text: *If what I have written could be transferred to typed text, in this way I could share my schedule to others and coordinate with others* (V2R2P9).

Participants suggested that digital pens would be more appealing if they included more customization of the pen buttons. One noted: *Instead of choosing options from the screen, if there are buttons on the pencil to change the mode to eraser or highlighter, it would be even more helpful in my case because many times I want to switch between these options while reading or drawing* (V2R2P3). Poor user interface design also deterred some users. One participant described a frustrating experience: *I have used a digital pen only once to create a to-do list. I had a very bad experience [...] it was difficult to traverse between paintbrush and eraser. [...] I lost my thought process* (V1R2P6).

5.3.2 Gaps in User Understanding. Another significant barrier to using digital pens for planning was participants' lack of understanding about how to fully utilize the tools. Participants felt that they were underutilizing the digital pen because they did not understand all of its features. For instance, one participant commented: *More explicit instructions on different functions of the pencil would be useful. The pencil came with minimal instructions, and while I find it very useful and I can do what I wanted to do, there could be other functions I'm less aware of* (V2R1P1). This lack of guidance left participants feeling as though they were missing out on features that could make planning more efficient. While some participants found the digital pen easy to start using, there were still challenges when trying to fully utilize its features. One participant reflected: *It was easy to learn how to use this product, but there were some things that took a bit of time to figure out. For example, I had trouble figuring out how to get the cursor back on track after making edits if I did not do them in order (like if I wanted to make a change).* (V1R1P18). Participants also mentioned that if they knew how to use digital pens for more advanced planning techniques, they would be more inclined to adopt them: *I have not used a digital pen to plan when to do tasks. I think I would use it if I knew how to do an equivalent of bullet journaling. I think an app that would help me personalize a calendar would be great, and a variety of digital writing tools* (V1R1P3). Some participants were hesitant to adopt digital pens without more evidence of their reliability: *I would like to see some demonstrations and testimonials of how the digital pen works in practice before I decide to use it for my calendar* (V2R1P11). Therefore, there was uncertainty around whether digital pens can truly replace more traditional or established digital planning tools in practice.

5.4 Theme 4: A Need for Tools that Adapt to User Practices

Participants emphasized the need for tools that align with their practices, suggesting improvements in integration, customization and conversion features.

5.4.1 Integration Improvements. Many participants expressed a need for better integration between digital pens and other apps, such as calendars, to-do lists, and software for work tasks. As V1R1P1 noted: *I use a weekly template and daily planner, updating the daily planner each evening based on progress and commitments. This approach is flexible, allowing easy task transfers. Integration with my calendar for automation would be helpful.* Integration between handwritten notes and digital platforms was seen as essential for increasing the functionality and convenience of digital pens. One participant noted the difficulty of switching between paper and digital calendars, saying: *I think that if I could just write in my paper planner and have it sync with my digital planner somehow—that would be really helpful!* (V1R1P14). Another explained the frustration of being unable to integrate their planning into live calendars, stating: *What didn't work well was I couldn't integrate this with any live calendar as this was on Procreate. If there was a way to export this into an actual calendar, it would have been great so that I could get reminders* (V1R2P3). Participants also wanted better integration with work tools, such as PDFs and Adobe software: *It would be helpful if the pen worked better with Adobe software for highlighting, underlining, and annotating PDFs, as it's currently too fiddly to use effectively* (V2R1P2). A noted limitation of digital calendars was their fragmentation of tasks: *It can be hard to find a place where all your events are listed together—you might have one calendar for work,*

another for social events, etc., making it difficult to see everything at once (V2R1P8).

5.4.2 Customization Improvements. Participants expressed a desire for ready-made visual aids and customizable templates to make digital planning more creative and personalized: *I'm particularly interested in digital planners that allow me to create custom templates* (V1R1P19). They wanted the ability to easily incorporate visual elements such as emojis, doodles, and tick boxes to improve their planning experience: *What would encourage me to use [a digital pen] would be easy-to-use ready-made visual aids (kind of like emojis) that could be added to make the page visually more appealing and aid with navigating the to-do list* (V2R1P6). A noted limitation of digital calendars that digital pens could address was their lack of customization with respect to aesthetics: *There isn't much room for creativity to make your calendar look and feel nice. If you enjoy decorating or adding personal notes, an online calendar may not suit you* (V2R1P8).

5.4.3 Conversion Improvements. Participants appreciated the possibility of digital pens being able to recognize and convert handwritten notes, drawings, and mind maps into more structured tasks or planning elements. They saw this feature as a way to bridge the gap between creative planning and digital task management. One participant imagined: *Using a feature like drawing out a mind map helps with thinking about the component parts of a big project. I think it would be super useful if there were a feature whereby all of the elements of the mind map are automatically converted into to-do list items* (V2R1P5). Another noted: *I think it would be really helpful if I could categorize or prioritize tasks with simple notations or doodles. For example, if something is important, I may draw a little star over it, then this will be converted to the top one on my list* (V2R2P24). Automatic tick boxes was another idea: *Same thing with maybe little automated tick boxes for each item, so they wouldn't have to be drawn separately* (V2R1P6).

Participants also expressed interest in incorporating voice-based functionalities to enhance planning. For instance, one suggested: *If there was a digital pen that could record my voice and make a to-do list automatically, it would be a handy tool for keeping track of things without much effort* (V2R1P7). Another noted the value of voice transcription for meetings: *Save voice clips when I'm speaking to someone and automatically transcribe them into text—this would be really nice in meetings where I need to take notes while listening* (V1R1P13).

6 Phase 1: Discussion

Participants preferred pen-and-paper planning tools for its simplicity and emotional satisfaction, extending prior findings on the cognitive and emotional benefits of handwriting [6, 31]. However, practical limitations—lack of integration, difficulty in organization, and risk of loss—often led them to adopt digital tools. More than half (41 out of 74) used digital pens for planning, demonstrating their potential to make a meaningful addition to the ecology of planning tools. Importantly, most participants combined digital pens with other applications, manually transferring information between note-taking apps, task managers, and calendars. As shown in Figure 3, participants frequently paired digital calendars with handwritten planners or integrated sketches with typed lists. This fragmentation reveals the need for multi-platform and multi-input support, where handwritten plans can be embedded with and, when needed, converted to typed-in, and integrated across tools.

While these challenges exist in many tools, typing-based systems have addressed them more effectively. Planning apps like Microsoft To-Do integrate with Outlook, allowing emails to be converted into tasks, while Todoist synchronizes across multiple platforms, and Sunsama integrates tasks from multiple task sources. Note-taking apps like Nebo offer rich conversion support. There are no existing apps that blend in the functionalities of planning and note-taking apps. Existing digital pen planners (e.g. Ajournal) remain siloed and limited in features, functioning primarily as templates replicating analogue planners.

To move beyond replication, our findings suggest that digital pen-supported planning tools should focus on three key areas: integration, customization, and conversion. Integration involves reducing the fragmentation of tasks across sources. Customization involves support for editable templates that can adapt to user practices, handwriting styles, while providing rich drawing support. Conversion involves handwriting recognition that categorizes and structures input into tasks or elements, such as recognizing symbols like stars for priorities or automatically converting written tasks into checklist items.

However, while these requirements align with the identified user needs, they remain conceptual—raising the question of how users actually interpret and respond to them. As Velt et al. [39] emphasize in their study on HCI theory and design practice, the gap between research and implementation often stems from the challenges in translating abstract, high-level concepts into concrete, actionable tools that professionals can use in their daily work. This necessitates an exploration of how concrete features can be designed and combined to offer effective planning support for digital pen users.

7 Phase 2: A Scenario-Based Design Activity with PenPlan

In Phase 2, we conducted a scenario-based design activity using a low-fidelity prototype as a boundary object [36] to bridge researcher and participant perspectives and encourage reflection on how digital pens could be better integrated into planning practices. We created PenPlan, a digital mock-up that embodied key design ideas emerging from the survey study. Unlike a usability test, this approach was not about assessing the effectiveness of the prototype, but rather about eliciting user perspectives, surfacing tacit knowledge, and uncovering latent needs related to digital pen planning.

7.1 The design of PenPlan

PenPlan incorporated features that aligned with survey findings about integration, customization and conversion support, drawing inspiration from existing typing-based planning and note-taking applications, as well as novel features which emerged directly from participants' suggestions. To facilitate discussion and engagement, we developed a polished but non-interactive Figma mock-up, aligning with trends favoring visually refined early-stage prototypes [13]. PenPlan includes eight main features:

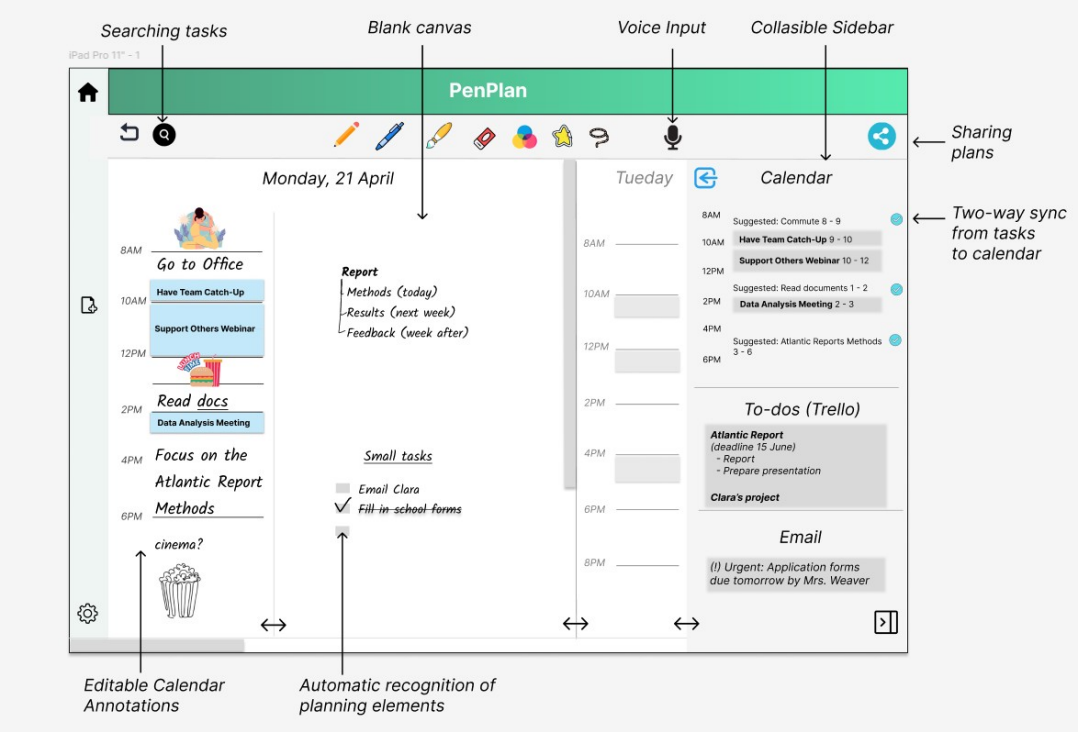


Figure 4: The design of PenPlan with pointers to its eight key features.

(1) *A blank canvas for freeform writing and drawing.* This feature, commonly found in note apps, responded to participants' preference for customization of handwriting, catering for the cognitive and aesthetic benefits (Theme 2) of pen-and-paper absent within typing-based digital tools. It offers a dedicated space for drawing with functions such as choice of different pens, colours and stickers.

(2) *Collapsible sidebar with sources of tasks.* This feature integrates tasks from different sources, such as emails or calendars, into one side-panel. This functionality directly addressed the challenges highlighted in the survey regarding the need for integration of planning tools (Theme 4.1). These sidebars are relatively new and uncommon in typing-based apps (recently explored in research [40] and in some apps, e.g. Sunsama reviewed in [3]) and absent in the out-of-the-box apps compatible with digital pens.

(3) *Editable calendar annotations.* This feature allows users to transfer a copy of the calendar displayed in the collapsible sidebar onto the blank canvas, enabling them to draw, annotate, and edit directly on top of it. It allows for customization of plans that goes beyond analogue-like templates (Theme 4.2).

(4) *Two-way sync from tasks to calendar* The two-way sync feature was designed to further explore new ways to integrate more closely handwritten plans and digital tools for planning, and answered user needs for seamless synchronization (Theme 4.1). It allows for tasks written on the editable calendar in the canvas to be automatically transferred as suggestions into the calendar side-bar.

(5) *Automatic recognition of planning elements* This feature converted handwritten elements, such as squares, into check boxes. It has been previously suggested in recent research on reusable ink systems [34]. It is directly linked to the need for recognition and conversion of planning elements in notes, where participants wanted tools to automatically convert handwritten content into structured tasks (Theme 4.3).

(6) *Searching previous tasks.* This feature allowed previous handwritten and typed in tasks to be searchable, directly responding to the needs of survey participants for information retrieval, allowing for conversion of handwritten tasks to searchable items (Theme 1).

(7) *Sharing plans through a link.* This feature allows users to generate a shareable link for their plans. It is commonly found in typing-based planning apps. It aligns with survey findings where some participants emphasized the need for better collaborative tasks in planning tools, such as syncing schedules with colleagues (Theme 3.1).

(8) *Voice control.* This feature allows users to add or manipulate tasks using voice input, either through a microphone embedded in the digital pen or via an on-screen button using the computer's microphone. This novel feature was linked to the survey findings for converting voice input to commands (Theme 4.3).

7.2 Participants, design and procedure

Five participants with HCI backgrounds, all experienced in using digital pens for work, took part. The design activity followed a scenario-based approach, where participants were shown a user story featuring a fictional professional, Alex, using PenPlan in a work contexts. Alex had a similar occupation to the participants - he was a user researcher in a company, and participant were asked to imagine being in his shoes. They were shown a slideshow of PenPlan's main eight features during a session conducted online. An example from the story is: *Alex wonders what his schedule and tasks look like for the day, and clicks on the Tasks icon to see his tasks from his other planning tools.* The Tasks icon was highlighted in the slideshow and the next slide showed what would happen when he presses on it. Participants did not directly interact with the prototype or with a digital pen during the activity. To gather responses, we opted for a semi-structured survey. After all features were demonstrated, participants were then asked to rate each one on a scale from 1 to 5 and to respond to open-ended questions about what they liked or disliked.

7.3 Phase 2: Findings

7.3.1 Searching previous tasks. The search feature was ranked among the highest, with a rating of 4.6 out of 5, appreciated for its potential to *solve one of the big drawbacks of handwritten content* (P4). However, similarly to the Phase 1 findings, the potential difficulty in recognizing messy handwriting was a concern: *This is useful, but if my notes are messy or shorthand, it might not be as effective as I'd hope* (P5). Participants were unsure about its accuracy: *Would give a 5 if it worked well. But I would give it a 1 if it only worked some of the time* (P3). As a way to solve this problem, P2 noted that this feature could be improved if it supported more than just keyword searches: *If my handwritten notes are quite informal, I may struggle to remember keywords. A search function that supports visual search, like recognizing layouts or colors, could be more helpful.* Another participant proposed tagging or categorization to enhance retrieval: *Maybe there could be tags to help with search and categorization* (P1).

7.3.2 Collapsible sidebar with sources of tasks. The sidebar was highly rated with 4.6 out of 5. Seeing tasks from multiple sources provided a sense of control and allowed for better task alignment with overall goals. P5 noted: *I think it's really useful to have 'already committed' tasks and calendars visible and all in one place to draw from when handwriting notes/planning.* This idea seemed so intuitive that many thought it was already available in common apps: *I immediately thought it was a neat concept as soon as I saw it, and I wondered 'Is this a real app I can get?'* (P3). However, the efficiency of integration with existing tools was a concern: *Looks great, but only if it connects to tools I already use* (P2). Suggestions included better filtering and customization to prevent information overload: *It should remind me of deadlines without making me search through emails* (P1).

7.3.3 Editable calendar annotations. was rated 4 out of 5. The ability to *scribble* directly on the calendar added a sense of *freedom and creativity.* Participants found it helpful for separating private and professional plans, allowing both to coexist without overlap. P2 valued the visual organization: *This allows to view and annotate tasks in real-time without disrupting the overall schedule.* However, maintaining organization was also noted as a challenge: *While writing on the calendar is helpful, keeping it clean and legible requires additional work* (P5). Participants wanted the tool to adapt to their planning style rather than vice versa: *Since my notes can be labyrinthine, I'd need to give a date stamp… it relies on me changing how I plan* (P4). P3 also questioned its necessity, asking: *If the same notes can be typed and synced automatically, why handwrite them?* P4 suggested scaling and resizing options to accommodate different handwriting styles: *Handwriting and digital writing are different in size, so it might be hard to fit everything in a small calendar.*

7.3.4 Two-way sync from tasks to calendar. was rated 3.8 out of 5. It was appreciated for different benefits. For example, P2 noted: *It's handy for drawing a distinction between private notes and more publicly available calendar information.* P5 valued the ability to keep plans flexible: *I like that my handwritten plans, which might change, don't get committed immediately into a digital calendar.* P5 also suggested features like visual fading of task suggestions to reduce clutter. However, some participants found the manual approval process inefficient. P2 remarked that approving tasks *makes me go through the planning process twice.* Concerns about handwriting recognition accuracy were also expressed, with P3 stating: *I would probably trust manually adding tasks to the calendar over handwriting recognition.*

7.3.5 Automatic recognition of planning elements. This feature was rated 3.6 out of 5. Participants appreciated its time-saving potential and intuitiveness, particularly if it integrated with external apps like Trello or Reminders (P1). Some found it useful for breaking down large tasks into smaller ones (P2). However, its necessity was questioned. P4 worried it diminished the personal touch of handwriting, while P3 doubted its ability to accurately interpret informal or complex notes. P5 highlighted concerns about false positives, stating: *It needs to be smart enough to distinguish between actual checkboxes and diagrams—otherwise, it could be frustrating.* Manual confirmation options were suggested to avoid automatic misinterpretations.

7.3.6 A blank canvas for freeform writing and drawing. averaged a rating of 3 out of 5. Participants appreciated its flexibility for *brainstorming* and *revising* plans, with P2 noting the natural feel of being able to *draw, write, and erase as needed.* P5 likened it to a portable whiteboard, particularly valued for aesthetics and quick edits. However, the lack of predefined structure posed challenges for larger or long-term projects, leading to potential *messiness* and difficulties in managing multiple tasks (P1). Some participants suggested optional templates or customizable structures, such as a date field or automatic organization of written tasks into a timeline, to improve usability.

7.3.7 Sharing of plans through a link. This feature received a relatively lower rating of 2.8 out of 5. Participants who rated it positively appreciated its potential for supporting collaboration, with P3 noting: *This could be handy for sharing quick updates with my team without needing to export or copy-paste information.* However, concerns about privacy and relevance limited its appeal. P4 stated:

Functionality	Rating (out of 5)
Searching Previous Tasks	4.6
Collapsible Sidebar with Sources of Tasks	4.6
Editable Calendar Annotations	4.0
Two-Way Sync from Tasks to Calendar	3.8
Automatic Recognition of Planning Elements	3.6
A Blank Canvas for Freeform Writing and Drawing	3.0
Sharing Plans Through a Link	2.8
Voice Control	2.2

Table 1: Rank-Ordered Evaluation Ratings of PenPlan Features

My notes are too personal to share as they are—this would need more controls to be useful. P5 echoed this concern, questioning what exactly would be shared and whether privacy settings were clear enough: *I would worry about what they can and can't see—is it my whole calendar? Just my notes? The privacy barriers need to be explicit.* Additionally, P3 found the feature unnecessary for personal use, noting: *I rarely need to share plans, but if I did, this would be convenient.*

7.3.8 Voice control. This feature received the lowest rating of 2.2 out of 5, with participants questioning its relevance in a tool designed for visual and tactile interaction. Many found it redundant, as existing devices like smartphones and smart assistants already provide robust voice-based functionalities. P1 remarked: *I love my pen, but I don't talk to it!* P4 saw potential value for hands-free note-taking, but overall, its purpose within a digital pen context was unclear. P3 questioned: *Not sure what I'd be asking it to do that my phone or Google Home can't already.*

7.4 Phase 2: Discussion

The design activity reported in Phase 2 built upon the insights gained from the user study reported in Phase 1, by using PenPlan as a boundary object, enabling us to elicit participant reactions about key design directions and bridge their perspectives with those of the researchers. The findings provide deeper insights into the implementation of integration, customization, and conversion in digital pen-supported planning.

7.4.1 Design priorities for improving integration of tasks across tools and people. Integration was best supported through the collapsible sidebar and the two-way sync, which helped to consolidate tasks from multiple sources, and least effective through task sharing via links, as participants primarily viewed digital pens as personal planning tools rather than collaborative ones. The two-way sync feature does not currently exist, however participants' reflection pointed out that it may be redundant or inefficient as manually approving each recognized task added an extra planning step. This suggests that two-way sync should allow *batch approval* or *smart filtering* to reduce manual effort.

While the sidebar exists in some typing-based apps and research prototypes [40], its significance for a digital pen context had not been previously investigated. The strengths and concerns of the sidebar were similar to those in typing-based contexts, such as the ability to gain an overview as a strength and doubts about whether the app would integrate with the right tools people use—but also different in key ways. For instance, reviewing task lists and emails while planning with a pen may be more of a diversion, as users are holding the pen and engaged in a more tactile, focused process (e.g., P1 comment). Therefore, the main design priority would be to have a *targeted suggestions* feature where all tasks of potential interest from other sources are visible at once, minimizing the need to manually sift through sources. Additionally, the type of suggested tasks matters: for digital pens, it is important to surface tasks that are "already committed" (P5) as users prefer to reflect, draw, and structure upcoming work rather than focusing on immediate execution. This contrasts with typing-based systems, where suggestions often center around daily tasks (e.g., Microsoft To-Do's smart suggestions feature pulling all tasks that may be included that day, irrespective of their structure).

Another way to integrate tasks would be to share a link to the tasks for other people to see. However, collaborative features are unlikely to be the default user preference and may only be needed in specific and less frequent scenarios. More importantly, users may be unwilling to engage in digital pen-based planning within apps that are inherently collaborative, even if they never need to share their plans. The perception of shared digital workspaces may feel privacy-intrusive, akin to making a personal paper planner visible to colleagues [25]. Even when planning alone, users might be deterred from apps that make their planning environment feel public. Tools should give users full control over visibility settings to avoid the perception of intrusion to ensure that the act of planning remains a personal and reflective experience [32].

7.4.2 Design priorities for improving customization of plans. Customization was most valued in editable calendar annotations, which added a sense of freedom and creativity, while the blank canvas was the least effective due to its lack of predefined structure, making it difficult to manage planning over the long-term.

Annotating a template of the calendar that contained the scheduled tasks was highly rated however participants raised concerns due to clarity and legibility. This finding suggests that while the idea was useful, its implementation could be different. One promising design priority is the concept of *dynamic templates*, where planning templates evolve in response to user input and external changes. For example, a calendar template could automatically update as events are rescheduled or tasks shift to preserve both flexibility and structure. Further, dynamic templates could be suggested based on the user's planning style. For example, if a user jots down urgent tasks, the system might suggest an "Important Today" layout with checkboxes, priorities, and deadlines. If they start sketching connections between ideas, a brainstorming template could appear, helping to structure thoughts while keeping flexibility. Since digital calendars are not ideal for freeform planning, dynamic templates would offer a more suitable format. This approach also addresses survey findings, where users wanted tidier plans but found blank canvases too unstructured and messy. Finally, planning themes could offer users the ability to customize the visual style of their planning surfaces, allowing for different levels of structure, color usage, and embellishments [42]. For example, some may prefer a minimalist design for clarity, while others may opt for colorful and heavily decorated layouts [7].

7.4.3 Design priorities for improving conversion of plans. Conversion was best supported through the search and the automatic recognition of planning elements, which helped retrieve and structure handwritten content, while voice control was the least useful, as it did not align with how participants typically interacted with digital pens. Given concerns about the feasibility of automatic recognition of handwritten elements, a more effective approach may be dynamic templates applied selectively—an "enhancer" feature where users highlight an area, and the system tidies it up, recognizing elements. For example, if squares appear next to tasks dated for today, the system could suggest converting them into a structured daily task list, reducing manual effort.

Further, to address participants' concerns, a smarter search function may be needed to go beyond keyword recognition to support visual search and contextual inference. Given the unstructured nature of handwritten notes, a keyword-based search alone may miss relevant tasks. Instead, AI-powered recognition could infer meaning based on handwriting styles, spatial layout, and recurring patterns in the user's planning. Additionally, a chatbot-style "ask your notes" function could improve retrieval by allowing users to query their handwritten content naturally. Instead of searching for exact words, users could ask, *"Find all tasks related to X client,"* and the system could infer relevance based on surrounding context, even if the keywords are missing. It has to be noted that the search function falls under conversion as it interprets and structures handwritten content, making tasks, deadlines, and priorities more accessible in digital format. However, it also supports integration by linking handwritten notes with external tools like calendars and emails.

Finally, voice input was not well received. Even participants who regularly used voice assistants like Alexa found it unnatural for planning, suggesting that general voice functions are unlikely to add value in digital pen-based planning. Further research is needed to identify specific contexts in which voice controls may become useful, for example, to facilitate daily work reflection [20] or other coaching-oriented features that could fit with the context of planning with a pen.

8 General Discussion

This study presents the first investigation of digital pen use for planning, offering empirical insights into its strengths and limitations while outlining key design priorities for future tools. It extends research on task planning and information management by examining how users navigate digital-analog hybrid planning [8, 18]. It also contributes to digital ink interface research [34, 42], showing how digital pens bridge unstructured note-taking and structured planning. Finally, it builds on work on feature adoption and usability barriers in productivity tools [41].

8.1 Augmenting, not redefining, user practices

A primary strength of digital pen-supported planning is its highly visual nature, providing a flexible and expressive alternative to typing-based systems while remaining easier to modify than traditional pen-and-paper methods. Since visualizability has been identified as one of the six key factors influencing task planning tool preferences [18], these findings highlight the potential of digital pens to bridge analog and digital practices. However, despite these benefits, participants still faced practical barriers when attempting to integrate digital pens into their practices. The fragmentation between handwritten and digital tools made it difficult to maintain structured plans, as existing note-taking apps failed to support essential planning functions like integration with calendars. This suggests that digital pen-based planning is not lacking in value but rather in seamlessly supporting existing practices [11].

These findings, gathered across both phases, suggest that digital pens are most effective when they augment—rather than redefine—how users already plan. Features that reduce effort by retrieving past tasks or pulling in relevant information were well received, as they enhanced planning without forcing users to adopt entirely new behaviors. In contrast, voice control and task sharing were the least valued features because they introduced unfamiliar interaction modes that conflicted with how participants naturally approached planning. Participants viewed digital pen planning as a personal, tactile process, centered on handwriting rather than on voice-input or on collaborating on plans with others. Designing for effortless integration, visually pleasing yet structured layouts, and intuitive automation—rather than forcing predefined or ill-defined structures—would likely increase the adoption of digital pens for planning.

8.2 The gap between planning and note-taking apps

Despite the increasing adoption of digital pens, existing digital ecosystems do not prioritize their use for planning, creating a gap in how these tools integrate into the broader set of productivity tools. Current solutions primarily fall into three categories: (1) freeform note-taking apps, which offer flexibility but lack structured task planning, (2) digital planners, which mimic paper diaries and calendars butlack advanced features and (2) task planning applications, which support structured planning but fail to accommodate

the fluidity of handwriting and visual planning. Neither fully supports digital pen planning, leaving users to manually bridge the gap between freeform and structured approaches.

This underexplored design space presents an opportunity for innovation. Should existing note-taking apps evolve to better support planning through intelligent structuring features? Should task planning tools integrate richer handwriting support? Or does this call for a new category of hybrid systems that seamlessly blend handwriting, structured planning, and automation? By framing digital pen planning as a distinct problem space, this study highlights the shortcomings of current tools and emphasizes the need for new approaches. Whether through extending existing applications or designing an entirely new ecosystem optimized for digital pens, addressing this gap is an important direction for future research and development.

This study does not provide a definitive answer, but it lays the foundation for future exploration. Given the design implications identified earlier, the most promising approach may not be to create entirely new standalone planning apps, but rather to extend the functionality of existing note-taking applications to better support planning. Note-taking apps already align most closely with digital pen users' needs (e.g. they provide smart global search, rich editing and drawing features), yet they require a few key extensions to bridge the gap with structured planning (e.g. targeted suggestions, dynamic templates, AI-powered recognition as outlined in the Phase 2: Discussion). In addition, apps that cannot achieve deep integration with other tools, such as the digital planner, focusing on rich drawing capabilities and a variety of adaptable templates could provide an alternative route. Supporting automatic organization and tidying features would help structure handwritten plans without forcing users to change their practices. Furthermore, template sharing features could cater to those with more reflective and personalized planning styles that tend to form communities around personal tracking practices [7].

8.3 Gaps in user understanding

Our findings reveal that many participants lacked a full understanding of their digital pens' capabilities for planning, often feeling they were underutilizing the tool due to insufficient guidance or awareness of available features. Some participants explicitly stated that they were unsure of the full range of functions their pen-supported apps provided, leading to missed opportunities for more effective planning. This highlights a broader challenge: even when well-designed digital pen planning solutions exist, users may struggle to adopt them without clearer affordances, onboarding, or demonstrations of their value.

This aligns with prior research on knowledge sharing in feature-rich work tools, which suggests that users often lack the confidence to explore or share knowledge about available features [41]. While some of the desired features—such as customization support—are already present in existing planning and note-taking apps, participants were often unaware of them or found them difficult to integrate into their routine. Rather than framing this issue as a usability barrier, it demonstrates the need for further research into how to support learning and discovery of complex work technologies. More intuitive affordances, contextual tooltips, or guided onboarding experiences could help users better discover and adopt existing planning-enhancing features.

8.4 Limitations

This study has several limitations. First, while interviews could have provided deeper qualitative insights, we opted for a semi-structured survey to reach a broader and more diverse sample. This approach allowed us to capture a wider range of experiences and perspectives, increasing the study's representativeness. To balance breadth with depth, we employed a two-phased approach: the second phase grounded conceptual design insights into concrete suggestions, ensuring a more comprehensive understanding of user needs. Thus, our methodological choice reflects a trade-off, with both approaches offering distinct advantages and limitations.

Second, PenPlan was presented as a static mock-up rather than an interactive prototype. While this served as a useful boundary object for eliciting reflections and shaping design priorities, a fully functional prototype would allow for a deeper exploration of how digital pens integrate with existing planning workflows. Future work could extend this study by incorporating usability testing with interactive implementations.

Finally, participants self-reported their level of experience with digital pens rather than demonstrating their usage directly. However, reliance on self-reports is a common and validated method in HCI research for capturing subjective experiences and behavioral patterns in personal technology use (e.g. [21]). While direct observation could provide richer behavioral data, prior research suggests that self-reports remain an effective and practical way to study individual planning habits in digital ecosystems. Future research could complement self-reports with observational or diary-based methods to further validate findings.

8.5 Conclusion

This study provides the first in-depth investigation of digital pen-supported planning, highlighting its cognitive benefits, aesthetic appeal, and potential for bridging analog and digital task management. Through a two-phase approach, we identified key barriers—including insufficient integration, customization, and conversion support—that limit digital pens' role in structured planning. The design activity with PenPlan revealed concrete design priorities, emphasizing the need for dynamic templates, targeted task integration, and AI-powered search to enhance usability and adoption. Our findings suggest that digital pens should not merely replicate analog tools but should offer distinctive digital affordances to support flexible, structured, and visually engaging planning. By addressing these gaps, digital pens can evolve beyond a niche note-taking tool into a fully integrated and intelligent planning assistant.

Contribution Statement

A1 led the conceptual framing, data analysis and writing, and created and evaluated PenPlan. A2 contributed to writing, the design of the study and supervised survey data collection. A3 contributed to the design of the study and supervised survey data collection. A4, A5, A6, A7, A8, A9, A10, A11 collected the survey data and conrtibuted to the design of the survey. A12 provided oversight and supervision of the project.

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