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# Reporting Experiences on Group Activities in Cross-Device Settings

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**Abstract**

Even though mobile devices are ubiquitous and users often own several of them, using them in concert to achieve a common goal is not well supported and remains a challenge for HCI. In this paper, we report on our observations of cross-device usage within groups when they engaged in a dyadic collaborative sensemaking task. Based on our findings, we discuss limitations of a state-of-the-art cross-device setting and present a set of design recommendations. We then propose an alternative design that aims for greater flexibility when using mobile devices to enable a free configuration of workspaces depending on users' current activity.

**Author Keywords**

Evaluation; cross-device interaction; group work

**ACM Classification Keywords**

H.5.2. User Interfaces: Evaluation/methodology

**Introduction**

Collaborative group tasks such as searching, organizing, or problem solving in general are usually facilitated by shared group spaces. In these spaces, tables are often used because of their physical affordances that are especially appropriate for group work activities [10]. Therefore conferences like CHI, CSCW, or ITS have closely investigated the impact of



Fig. 1: Tabletop size 10.6"



Fig. 2: Tabletop size 27"



Fig. 3: Tabletop size 55"

(interactive) tabletops on group work activities and related phenomena [4,8,11]. In addition, the applicability of activity spaces for multiple devices usage [3] and multi-screen environments for active reading [1] showed that cross-device settings feasibly support knowledge work. Based on such prior work, this paper aims at informing the design of future cross-device systems by observing how users make use of mobile technologies around interactive tabletops. To achieve this, we used a refined version of our TwisterSearch [8] system in a user study to observe group work activities in such a cross-device setting. TwisterSearch consists of two tablets for personal work and one shared tabletop for group work. The personal devices enable individual search and reading activities, while the shared group workspace enables structuring and sharing information shown as snippets during around-the-table collaboration. The system allows for a digital transfer of documents between all three devices.

Based on our results, we propose an alternative design for future cross-device settings that allows for a flexible configuration of multiple devices for collaborative sensemaking activities. This conceptual solution aims to move beyond traditional tabletop settings to support more complex device ecologies [3,5].

### User Study

We conducted an exploratory study in which three different tabletop sizes (see Fig. 1-3) were used as shared group spaces in a between-subjects design. In total, we investigated five dyads in each condition resulting in 15 dyads and 30 participants respectively. Each dyad was asked to work on the VAST 2006 Stegosaurus tasks [2]. This involved searching for relevant information in a data set of 238 documents,

images and data sheets. The aim was to find relations between these documents and come up with a solution to a hidden plot. Participants had 90 minutes in order to work on the task and find relevant information.

The focus of the evaluation laid on the investigation of the groups' activities as well as their collaboration behaviors. Based on video observations, our results report participants' experiences with the system. Limitations are identified and feed into the development of our alternative design that aims for a flexible configuration of personal and shared work spaces depending on the activity on hand.

### Results

In the following, we describe the main activities as observed in our study and discuss them in relation to existing work. Based on our findings, we formulate five recommendations for the design of future systems. They are shown in the side bar on the next page.

#### *Configuration of personal and shared spaces*

As intended, participants used the tablets in order to search and read the found documents. However, participants only shared a document on the table when they were sure that it was relevant. Often, they displayed the content of a document to their partner in order to ask for agreement to transfer it to the shared space. Even when adding documents to the table, participants tended to first keep the documents on their side of the table without immediately combining the results with their partner. It seemed that this was done to first get an overview over the found documents in private. Thus, we conclude that future systems should allow for a free configuration of private and shared work spaces (**R2**), which resonates with [11]'s findings.

## Recommendations

**R1:** Offer three views (search, read, collect) on all devices in order to break the dependency of functionality and device.

**R2:** Allow for a fluid transition of personal and shared space to enable users to decide when and how they want to publish their work.

**R3:** Allow for easy and seamless transfer of documents and search results between all incorporated devices.

**R4:** Allow for handover and sharing of devices.

**R5:** Allow for a flexible configuration of the shared space size to support a fluid transition of activities that need a large display size as well as division of labor.

### Document transfer

When working together, participants often utilized the possibility to transfer documents between devices. Users acknowledged this functionality. It was found to be very helpful and considered essential, and should thus be included in future systems (**R3**).

Furthermore, participants often showed documents on their tablet to their partner to share interesting findings, treating the tablet like a paper-document. However, participants were reluctant to give away their personal tablet as it was introduced as their personal device and they only had one of this kind. Thus, future settings should provide users with multiple tablets to support active reading [1] and to encourage them to handover mobile devices (**R4**).

### Device functionalities

The shared tabletop in TwisterSearch allows to visualize documents as a snippet to cluster them. This activity was found to act as a common ground for discussions about possible relations between the documents. However, participants first wanted to collect and sort their findings on their own before sharing their results with their partner (see **R2**). They did not have a possibility to collect or keep documents and search results on their personal device for further usage [3] as the collection of documents was bound to be done on the shared table. Similarly, when working on the table, participants often lost track of the content of the snippets and wished to view the content of the document. Thus, they sent the document from the table to their personal tablet to read it again. This was found to be a quirky work-around as it was not possible to seamlessly switch between the snippet-view and the detail-view on the shared work space. Thus, we

conclude that functionalities should be available on all personal and shared devices (**R1**). This would also allow for a better comparison of single documents when working on them as a group.

### Configuration of the workspace

Finally, towards the end of the session, participants made much more use of the table for clustering documents to externalize relevant relations between them. In addition, the shared table was used to gain an overview of the task progress. For these activities, a large display size was considered to be important. In addition, participants utilized the table to divide further tasks between them. This is similar to [6]’s activity of “divide & conquer” and [3]’s description of fragmenting resources across different devices. We thus propose to allow for an easy configuration of the workspace depending on the task at hand (**R5**).

In the following, we address our identified recommendations in a concept based on a flexible setup of interactive tablets that can be (de)coupled ad hoc depending on the current activities. We believe that especially in collaboration tasks where users frequently switch between different activities, such a flexible setup allows for a better adjustment of the system to the task at hand and current user needs.

## Concept

One of the main shortcomings of our system was found to be the forced distinction between activities that could be performed only on the personal tablet or only on the table. In order to break the dependency of functionality and devices (**R1**) and allow for a fluid transition between personal and shared work spaces (**R2**), we propose an interactive setting consisting on a higher

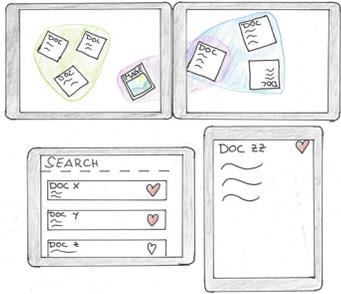


Fig. 4: Mixed Shared Workspace

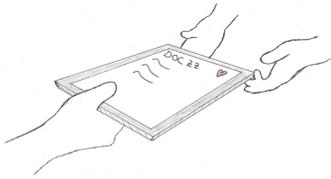


Fig. 5: Physical Handover

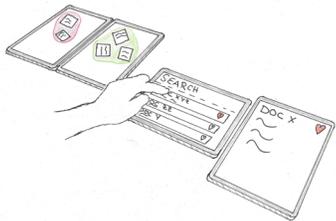


Fig. 6: Mixed Personal Workspace

number of tablets that can be freely configured spatially as well as content-related. This accounts for users' extensive device ecologies of up to ten interactive devices [5] allowing for their utilization as a single device as well as offering the possibility to connect several tablets and treat them as a larger interactive surface to perform shared activities (**R5**) (see Fig. 4). This also loosens the borders between single-user and group-based activities (**R2**). Users are able to perform actions in the same fashion in several phases and on multiple devices of their group work session.

The concept still utilizes one view to search and one to read documents. In addition to this, we add a third view to allow organizing, sorting and clustering of documents on single tablets in the same manner as in the previous tabletop system (**R1**). Thus, the snippet-view does not only act as a container for *shared* documents but as an alternative interactive visualization of search results. Users can find connections or dismiss irrelevant information more easily and with a higher visibility. As the basis for each of the three views are the found documents, changes to them in one view will instantly take effect in other views (**R3**). Seamless transitions between all views are provided, e.g. documents can be read by tapping on a search result or snippet.

In addition, users are able to use multiple tablets. The higher number of tablets on-hand might lead to a change of perspective: The former one-to-one distribution of tablets lead to a perception of personal devices – providing multiple tablets per persons might change this to temporarily personal or activity-based device perceptions [3], encouraging users to use

multiple tablets at the same time, each both, separately and combined (**R5**) (see Fig. 4 & 6). This allows users to read various documents whilst engaging in visual structuring activities at the same time [1]. In addition, users can combine multiple tablets to a larger interactive surface (**R5**) using technologies like [7] or [9]. The additional space can be used to organize or sort documents in a private session, without having to interrupt group partners or overcome personal barriers (**R2**).

The flexible work space can be rearranged as shared space and tablets can be added or removed at any time allowing multiple users to work together by adding their tablets to build a larger interactive shared work space (**R2** & **R5**). This flexibility might help to support group activities like the division of labor as each user can take a device to further investigate information. Interesting documents can be transferred to different devices (**R3**) or handed over physically to each group member (**R4**) (see Fig. 5). Thereby, the perception of devices might change, as they no longer appear as tools to search and read, but as physical manifestations of digital documents.

## Conclusion

Overall, our concepts allows for a flexible and tailored use of space, smoothly adapting to changing requirements, the experience of which goes beyond the usage of a single large screen [1]. As [3] suggest, we aim for a light-weight setting that does only afford minimal configuration work to allow users to dynamically relate interconnected devices to best support the activity at hand.

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