# Designing for Improved Brainstorming

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## ABSTRACT

This paper describes a design for improved brainstorming. Brainstorming is a widely used technique for idea generation. While this technique has many positive aspects, it also suffers from a number of problems. These problems range from social problems to productive problems. Many variations of brainstorming such as traditional and electronic brainstorming exist, but neither can completely take away the problems: with overcoming one problem, new ones are introduced.

We aimed to design a system that solves the problems by combining aspects of both traditional and electronic brainstorming methods. The result of our design process is a brainstorming system that uses an interactive table and a wall screen. In this paper, we lay out the most common problems of brainstorming sessions and describe how our system solves or eases these problems. We describe in detail how the system works and the intended human interaction with this system.

## INTRODUCTION

Brainstorming is a group activity designed to generate a large number of ideas in order to come up with a good solution for a problem in a short time period. Our project aim is to design a system that improves brainstorming by making it easier to generate ideas and yield more valuable results.

The brainstorming system is to be used in a university setting. The group members participating in the brainstorm session are relatively equal in that no boss or supervisor will be present. The culture can be described as 'wanting to learn'. From our own experience we know that coming up with ideas is not always easy. Therefore one of our ideas for improvement was to create a system that will help us with generating ideas. Being able to access outside information sources will be one feature we would like to implement.

When facilitating brainstorming, there are some features that pop out as being important. For example, digitalizing the output of a session will save one person from the ungrateful task of putting all the scrabbles on post-its in one digital document.

In this paper, we describe a design for an improved brainstorm system and the concepts we used in the design. We first explain the intentions for brainstorming practices. Next, we describe the factors that make brainstorming unproductive and how these factors can be countered. We define the users that we designed this system for and why they would need this system. To address the problems more clearly, we created a use case scenario. Based on these problems, we formulated requirements and from these requirements established a design concept. In the Methods section, we describe in detail how the system works, we motivate our design choices and we describe the human interaction with the system. In the Discussion section we address the limitations and issues of the system, and solutions to some of the issues. We also describe problems we foresee for our system. The Conclusion section sums up the main points from the project, the lessons we learned from the project and we hint at how our system could be extended by future researchers.

## BRAINSTORMING

Brainstorming is a group creativity technique designed to generate a large number of ideas for the solution of problems. It can be a powerful technique, because it can create new ideas, solve problems, motivate and develop teams. The focus

is on quantity rather than on quality to enhance a divergent production. It is aimed at solving problems through the quantity of ideas. The assumption is that the greater the number of ideas generated, the greater the chance of producing a radical and effective solution. But to be effective, it needs to be structured and follow brainstorming rules.

In this paper we distinguish between two dominant forms of brainstorming: traditional and electronic brainstorming. With traditional brainstorming, we mean co-located collaboration in which ideas are written down on paper. With electronic brainstorming, we mean distributed collaboration that is computer mediated.

Although brainstorming has become a popular group technique, when applied in a traditional group setting, researchers have not found evidence of its effectiveness for enhancing either quantity or quality of ideas generated. Even though traditional brainstorming may not increase the productivity of groups (as measured by the number of ideas generated), it may still provide other benefits, such as boosting morale, enhancing work enjoyment, and improving team work. Attempts have been made to improve brainstorming or use more effective variations of the basic technique. From attempts to improve brainstorming, electronic brainstorming stands out as being the most productive (Hilliges et al., 2007). Mainly through anonymity and parallelism of input, electronic brainstorming enforces the ground rules of effective brainstorming and thereby eliminates most of the deleterious or inhibitive effects of group work (Nunamaker, Dennis, Valacich, Vogel & George, 1991). Because of problems such as distraction, social loafing, evaluation apprehension, and production blocking, traditional brainstorming groups are little more effective than other types of groups, and they are actually less effective than individuals working independently (Mullen, Johnson & Salas, 1991). Social loafing is the phenomenon of people making less effort to achieve a goal when they work in a group than when they work alone. Performance is found to decline with increasing group size. Research has demonstrated that when outputs are identifiable and individuals are held accountable for their outputs, the loafing effect is eliminated (Latane, Williams & Harkins, 1979). The loafing effect has been demonstrated with a variety of tasks including brainstorming and vigilance (Harkins & Petty, 1982). People working in groups tend to focus their discussion on information that is common to most members at the expense of unique information known to few members. Groups often emphasize their initial point of view during discussion, leading the group to make more extreme decisions than what individual members would do on their own. Groups that are cohesive may strive for consensus to such a degree that they neglect information which threatens group unity. Choo (2007) made several recommendations to overcome these problems in group brainstorming, that we can use as requirements for our system:

- increase information and knowledge sharing before the start of group decision process, thus enlarging the pool of common information.
- differentiate expert roles based on group members' specialization and experience, so as to encourage the introduction and use of unique information.

Brainstorming can be considered successful when a large number of unique ideas are generated.

One way to enhance the consideration of uncommon or unique information is to assign expert roles to group members. Research has generally found that groups are more likely to discuss unshared information and correctly solve a hidden profile when members are known experts. Assigned expertise has increased the mentioning and repetition of unique information (Stasser & Birchmeier, 2003). This leads to the following requirement for our system:

- make information more assessable (easier to evaluate) during group deliberation.

Providing access to information during discussion can enhance group information processing. Research has shown that members

who kept their information sheets during discussion mentioned more information than those who relied on memory (Hollingshead, 1996). Thus it would be great if our system could:

- make information more accessible (easier to retrieve) during group deliberation.

Parks and Cowlin (1996) noticed that unique information was more likely to be mentioned in groups when databases of information were available during decision-making and could be used to confirm information. Mentioning and repeating unique information became less risky because there was an objective way of verifying the information. Therefore it's important for our system to:

- engender a safe and open information culture that promotes information sharing and use.

## TARGET GROUP

Our target group consists of academics and students of the Faculty of Science (FNWI). The system is to be installed in one of the common rooms. It is aimed at people that happen to be in the room, come up with an idea and want to brainstorm about it. This is why the system was designed to allow users to immediately and intuitively use it. The system can also be used for those that come to the room with the intention to brainstorm. We designed the system based on a use case scenario which captures the main requirements of the system.

In the following scenario three academics are presented and an outline of the problem is given:

*Sandra (Physics), Bob (Astronomy) and Julie (Maths) are three academics that often gather in a room where they talk about anything. Usually they exchange ideas about running projects such as about building a new brainstorming system, game consoles, or science. They use words, drawings, and tables to express their ideas. Most of the time they come up with good ideas. One week later though, they have often forgotten what those ideas exactly were, as none of them had written it down. Sometimes Bob writes things down on paper, but only selectively, so not all ideas are written down. Moreover, when he brings it home with him, it often gets lost somewhere. It also happens frequently that they have to suddenly interrupt the brainstorming, because they have to give class. When they gather again later to resume the brainstorm which they had started earlier, they have often forgotten what they had come up with previously. It would be great if they could somehow store and retrieve the ideas they had. Even though they sometimes come up with good ideas, it also happens that they get stuck or run out of ideas. What they need is to somehow get inspiration for more ideas*.

## DESIGN CONCEPT

Research has stated that computer-supported brainstorming results in more number of ideas than verbal or manual brainstorming (Hilliges et al., 2007; Nunamaker et al., 1991; Streitz et al., 1999). However, there are some limitations to existing computer brainstorming systems (Hilliges et al., 2007). Traditional brainstorming on paper still has certain benefits over computer mediated systems for brainstorming, such as flexibility of input and work enjoyment. Both methods have their own benefits and problems, making neither superior to the other. We designed a brainstorming system by combining the benefits of both traditional and electronic brainstorming. We used aspects of brainstorming that make it useful to create new ideas, while we

also considered the factors that make brainstorming unproductive.

The brainstorm system consists of an interactive table and a wall screen, each with its own function. The interactive table is primarily used for writing down ideas, while the wall screen is primarily used for additional information. By separating the functionalities the brainstorm process won't be interrupted. The interaction with the table is done with stylus pens, while some actions are possible with fingers. The interaction with the screen is done with a virtual keyboard on the table. The wall screen can be used to look up additional information during a session or to display background information on a subject before the start of a brainstorm project. All sessions are automatically saved, which makes it possible to load a previous session on the table and proceed on the existing material. After or during a session, it's possible to see an overview of the sessions on a website.

How all these parts of the system work is explained in the next section.

## METHODS

### Interactive table

The interactive table supports multi-touch input, enabling multiple users to write on the table simultaneously. Several interactive tables have been developed who support this multi-touch input, such as the DiamondTouch table (Morris, 2006; Ryall, Morris, Everitt, Forlines & Shen, 2005). DViT (Digital Vision Touch) technology, used for interactive displays, allows multiple simultaneous inputs.

Things on the table are written with a stylus pen. They can be erased with the back of a pen. This resembles traditional brainstorming, where a pencil usually has an eraser at the back. There's

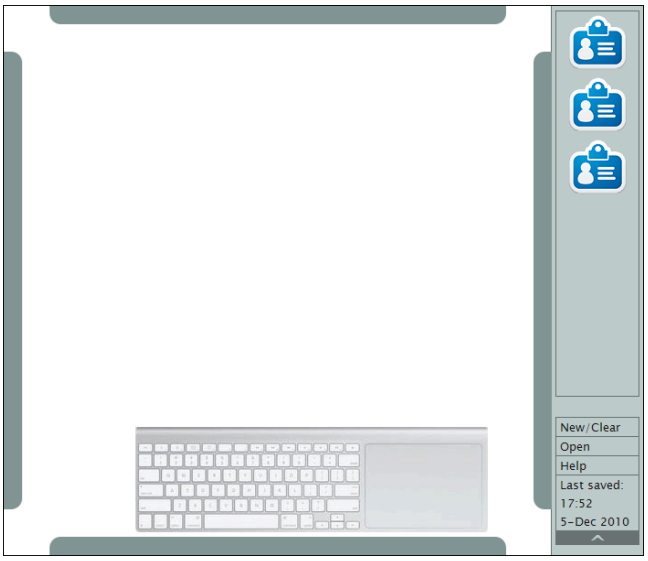



**Figure 1: The interface of the interactive table; the keyboard can be brought out by sliding out one of the grey edges; it can be hidden by sliding it back.**

also a button on the table menu to clear the entire table at once. The virtual keyboard consists of a keypad and mousepad. While it's possible for multiple people to write on the table, only one can use the keyboard at a point in time. This is to avoid situations where multiple people are typing: it wouldn't be clear for the wall screen which orders from which keyboard to follow. When the keyboard is used, people can continue writing on the table; this doesn't interrupt the sketching. The keyboard can be brought out onto the table by sliding out the keyboard edge at the outer lines of the table screen (see Figure 1). This is possible from every position around the table.

People can stand around the table from all angles and sketch from their perspective. To ensure users can share their ideas with others, the system makes it possible to slide and rotate items over the table. All they have to do is draw a circle around a group of sketches to group this together as one item (see Figure 2). The item can then be slided and rotated. The item can also be enlarged or scaled down by dragging two points of the

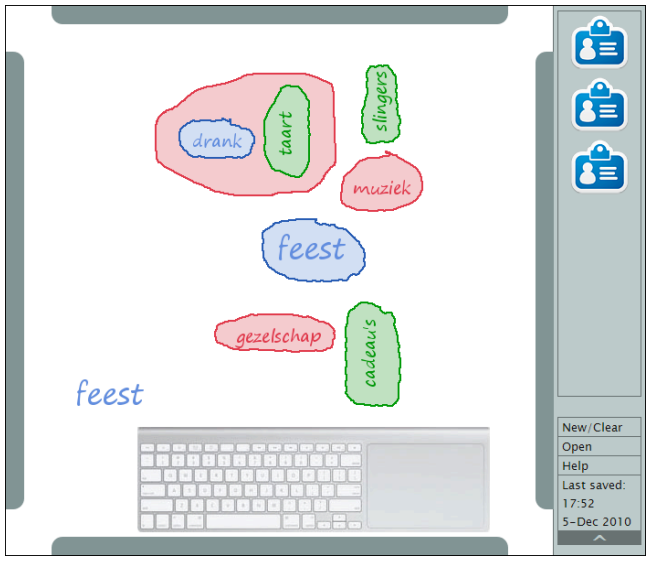



**Figure 2: Sketches on the table can be grouped as items.**

outside line further apart or closer together.
When sketches are grouped together as one item, it isn't possible to sketch in this area anymore.
This is to ensure that when touched, this can't be mistaken for sketching: a grouped item is only touched for sliding and rotating. You can edit the content by degrouping the sketches.
Degrouping is done by erasing a reasonable amount, about one fourth, of the surrounding line.
While sketching is done with a stylus pen, sliding, rotating and scaling can be done with fingers. We made this decision to ensure a natural interaction: in traditional brainstorming writing things down is done with a pen, but passing on 'items', be it pictures, post-its or notes, and rotating them is done with hands. Furthermore, two points have to be touched to scale an item, which isn't possible with one pen.

We have chosen to use an interactive table for the following reasons. First, we wanted to make the brainstorming as natural as possible to reduce the effort of learning. With our interactive table, users sketch their ideas with a pen in the same way they would sketch with a normal pen on a piece of paper. In this sense, brainstorming on an interactive table closely resembles traditional brainstorming (Hilliges et al., 2007). This flexibility of input favors an interactive table over brainstorming on a laptop which is limited to keyboard input: a major drawback of brainstorming on a computer is its limited options for unstructured note-taking (Barkhuus & Dourish, 2004). Moreover, in their research Ryall et al. (2005) found that users find an interactive table less intimidating than a traditional computer: they didn't view the table as a computer, which made them more willing to use it.
Second, we wanted the session to support group work. With one shared display everyone is working on, the information is accessible. People can see what others are writing, when they're having trouble, and easily share and discuss their ideas.
In their study, Ringel, Ryall, Shen, Forlines and Vernier (2004) divided an interactive table into different areas, where each user has a private area: documents in that area can only be accessed by him or her. The document can be dragged to a public area where everybody has access. We decided not to do this and made the entire table a public area, just as in a traditional brainstorming session. We did this because we wanted the session to be as collaborative as possible, without people becoming absent and working in their part of the table and not participating as a team.
Third, we wanted to combine the benefits of both traditional and electronic brainstorming. The benefits of traditional brainstorming are facilitated by the table in that users can sketch as they would on paper. The benefits of electronic brainstorming are facilitated by the table in that the written content on the tabel is digital: content

can easily be saved and shared, and sketches can be scaled and edited.

We have chosen interaction with a stylus pen instead of hands for a number of reasons. First, this resembles traditional brainstorming on paper with a pen. Second, research on interactive tables found that most people prefer interaction with a pen rather than hands (Ryall et al., 2005). Reasons for this preference include the finer input it enables and hygiene-related concerns: some were uncomfortable with many other people touching the table with their hands. While it is possible to use hands for sliding, rotating and typing, it's also possible to use the pen. Sketching is only possible with a pen. Scaling an item is only possible with hands or two pens, because two touches are required.

When multiple people are working around the same table, situations might occur where their actions conflict (Ryall et al., 2005). To overcome these conflicts, we made the following design decisions.

Possession of an item is arranged as follows: when user A holds an item and user B attempts to take it, the item stays with user A until this user lets go of the item.

The items can overlap. The item that is selected is on top of the table, appearing above other items.

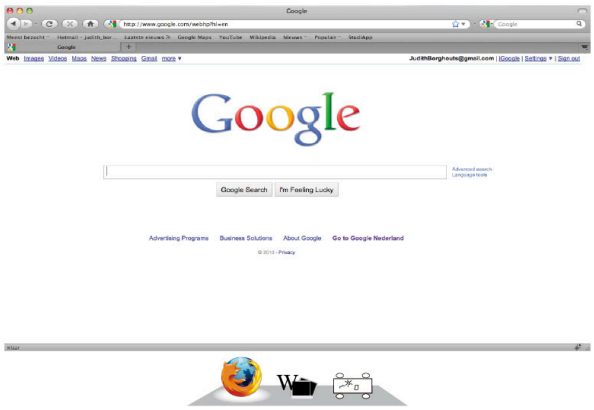
We wanted the table to be small enough to have a good overview of the entire table when standing around it, yet big enough for every participant to have enough space to sketch. Up to 8 people should be able to work with it at the same time. With these size requirements in mind, our table will be about 2.20m x 1.50m.

One problem with interactive tables is that people tend to lean with their hands or elbows on the table (Ryall et al., 2005). For a touch-screen table this can be problematic, as the leaning is interpreted as a touch. It's in particular problematic for our table, since the edge of the table display is used to bring out the keyboard. To solve this, our table has a black rubber frame on which the users can lean.

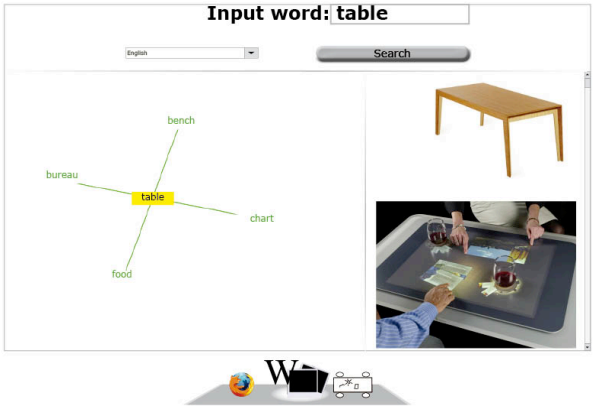
When approaching the table, a scanner will automatically scan the ID card of the user and display it on the right side of the table display. By touching a card on the display with a pen, the pen will be linked with that specific person. Everything written with this pen will have a specific color (see Figure 2). This way, everyone can see who wrote what, even after shuffling items. It's not mandatory to identify yourself: when not selecting any ID card, you will write in black, and you'll be able to write things anonymously.

The linking of input and identification eases some brainstorming problems: it is clear who wrote what, so it's easy to detect early in the process when someone has hardly contributed or hasn't contributed at all. This reduces the chances of social loafing. Furthermore, if you look back afterwards at a session and notice a sketched idea you'd like to know more about, you know who to contact because you know who has sketched the idea.

Because the system is set in an academic setting, we presume hierarchy problems will not be an issue in linking a person, and thus an expertise, with the input.




(a)

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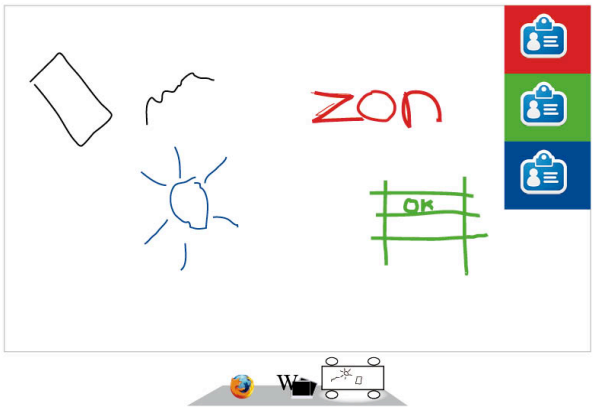


(c)

**Figure 3: The interface of the wall screen with the three modes (a) Internet browser; (b) a thesaurus and (c) a table overview.**

### Wall screen

When a person is exposed to several stimuli, (s)he is more likely to come up with new ideas (Hilliges et al., 2007; Streitz et al., 1999). For this reason, we included the possibility to look up additional information, as to inspire participants to come up with new ideas. This additional information also enables users to make information assessable, a requirement which was mentioned earlier. The display of the wall screen can be turned off when not needed, but remains on standby so only one button-click is needed to activate the screen again.

Actions on the screen are done with the keyboard on the table. The keyboard has a mousepad to move a cursor on the screen. All interaction is carried out via the table: the sole function of the wall screen is to display information. The reason behind this is to avoid that the brainstorming group would be divided in people working on the screen, and people working on the table.
The screen has three modes to choose from (see Figure 3):

1. An Internet browser
2. A thesaurus
3. A table overview

With the browser, normal Internet activities can be carried out, such as looking up background information about a certain subject. When this search doesn't yield a satisfying result or gives too much results, it's also possible to search on a word in the second mode. Synonyms will be given, as well as images and videos on the subject.
The third mode shows an overview of the content written on the table. This mode can be used when users want to view and discuss their ideas so far.

We have included a wall screen in our system for the following reasons.
We wanted to keep the table as empty as possible to give users enough room for sketching. To achieve this, the table is only used for sketching. We included an extra screen to display additional information.
Technology is often found disruptive to a brainstorming session (Hilliges et al., 2007). Usually one person looks up additional information on a laptop, causing the other participants to lose attention. A large screen displayed on the wall solves this problem: it makes the information accessible to everyone and makes everyone involved. Furthermore, the possibility to display large information structures at once provides new opportunities for innovative idea creation (Streitz et al., 1999).
While we aimed to make the table small enough for everyone to have an overview of the content, some prefer to have a vertical overview. The wall screen allows users to take a step back and discuss the result of the brainstorm session (Hilliges et al., 2007).

### Website

To make the information accessible, it's possible to view brainstorming sessions online (see Figure 4). This relieves users of the task to send and share the session. With viewing a brainstorming session, we mean viewing an overview of the table that shows all that's been sketched.
The sessions are automatically saved, but can also be explicitly saved by users, giving them the possibility to give the session a name and a description. The website resembles the functionality of Google Docs, but the main function of this website is to view sessions; nothing can be changed. Additional functions include printing table overviews, downloading

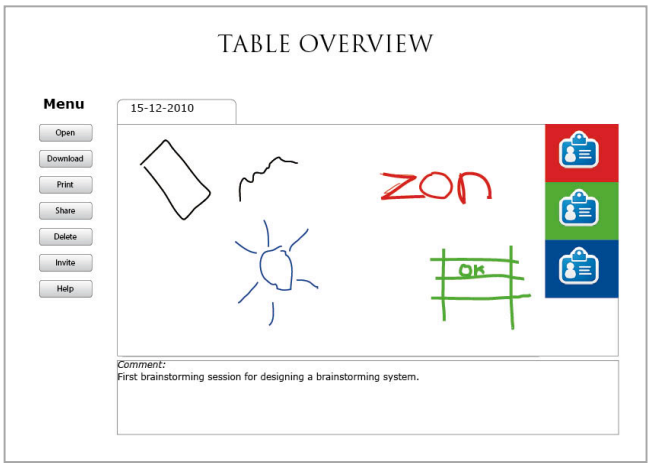


**Figure 4: Previous and current sessions can be viewed online.**

them as a file on your personal computer and sending them to people with no access to the website.
A visitor normally only has access to sessions (s)he participated in, to prevent a situation where a supervisor can monitor its employees. However, it is possible for a participant to give a non-participant access, for example when a colleague is unable to attend the meeting, but wants to be part of the brainstorming process.

We've designed our system to be operable in the common room. The system should support both planned as unplanned, spontaneous brainstorming. To facilitate spontaneous brainstorming, everything needed is present in the common room. The stylus pens are situated at the side of the table in a case, and internet is available on the wall screen, so no one needs to bring his or her laptop if internet access is needed at some point during the session. We presumed everyone has their ID cards with them at all times. Even this is not the case, it's still possible for users to sketch anonymously on the table.

## DISCUSSION

During the starting phase of our project, we had the idea to enable typing text on the table. A word could be clicked to make it the input word for the thesaurus on the wall screen. However, during trying out the interaction ourselves, we sensed that constantly shifting between typing with fingers and sketching with a pen can become tedious. We solved this by deciding to skip the function to type text on the table; all brainstorming is done with a pen. The sole purpose of the keyboard is to control the wall screen. This also deletes the possibility to click on a word and get information about it on the screen. We changed this to the action where you type in the word with the keyboard.

Another point of discussion was how many people could participate in a session. We wanted to facilitate for as much people as possible, yet we wanted the table to stay small enough for everyone standing around to have an overview of the table. To meet these requirements, we decided that up to 8 people can work together on the drawing table.

We weren't sure about an obvious action to degroup sketches. We considered a button in the corner of the grouped item, but could foresee the difficulties with accidentally touching the button while trying to slide, rotate or scale the item. After several considerations we decided that a user has to erase a part of the grouping line, since he wants to 'erase' the grouping of the sketches.

While these problems were initially a point of discussion, they were solved rather quickly. The biggest issue revolving around our work was what to show and what to hide on the interactive table. We aimed to keep the table as empty as possible so there would be enough room for sketching, yet we didn't want users to put too much effort in searching for specific functions.

In our final design, the table displays an area to sketch, the ID cards of the participants and a menu that can be slided out to choose from more functions (see Figure 1). The most used functions are visible, less important functions are hidden. The keyboard is also hidden, and can be brought out by sliding out the keyboard edge.

As we discussed earlier, our table is suited for about 8 people to work on. By providing the table with 8 pens, we can make sure only a maximum of 8 people will be able to sketch. However, problems might occur when more than 8 people try to stand around the table. People may get in the way of each other which will lead to irritation.

## CONCLUSION & FUTURE WORK

With our system, we aimed to solve or ease the common problems of brainstorming sessions.

In the process of doing so, we learned that brainstorming yields problems that are very different from each other and can't simply be solved. As electronic brainstorming has shown, by solving problems of traditional brainstorming, new problems may be created.

We tried to offer a brainstorming system that's superior to both traditional and electronic brainstorming methods by combining aspects of both methods. By doing so, we designed a system that makes it easy to quickly sketch ideas in a natural way. Ideas are saved and can be shared, and are instantly available to all participants of the session. When users get stuck, the additional information aids them in generating new ideas.

There were some options we discussed but eventually didn't implement into our design due to time constraints. Future work could be to

further explore the possibilities of these options. For example, when looking up additional information, users may come across certain information they'd like to save with the session. We didn't find a quick solution to enable this, so it would be interesting to explore this option in the future. When viewing a session at the website, additional information found during the session that was of particular interest would also be shown.

We discussed the possibility to drag items, such as images or articles, from the wall screen onto the table. Since discussing this made us hesitate if this was feasible, we soon put this option aside and focused on the other functionalities. However, several interactive tables that we came across in our literature review were solely used for sharing pre-existing documents. In the future, it might be interesting to explore combining both sketching and pre-existing documents on the table. We could examine if adding the possibility to drag information from the wall screen onto the table would be of use in brainstorming sessions.

An application that recognizes handwritten words would provide some extra useful options. The thesaurus program could display synonyms automatically after nothing new has been written for some time, based on anything that is written down. Unfortunately, current handwriting recognition applications are not reliable enough to facilitate this.

While our system is a step in the right direction, there's still enough work to do. Because the final version of our design is merely a mock-up, we weren't able to fully test the imposed interaction. A next step is to implement our design into a working prototype with an actual interactive table and wall screen, and do user testing with our target group.

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