An Investigation on Requirements for Co-located Group-Work Using Multitouch-, Pen-Based- and Tangible-Interaction

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Abstract. Cooperation and coordination is crucial to solve many of our everyday tasks. Even though many computerized tools exist, there is still a lack of effective tools that support co-located group work. There are promising technologies that can add to this, such as tabletop systems, multitouch, tangible and pen-based interaction. There also exist general requirements and principles that aim to support this kind of work. However these requirements are relatively vague and are not focused on concrete usage scenarios. In this study a user centered approach has been applied in order to develop a co-located group work system based on those general requirements but also on a real use case. The requirements are transformed into concepts and a running prototype that was evaluated with users. As a result not only the usability of the system has been proven but also a catalogue of even more specific requirements for co-located group work systems could be derived.

Keywords: multitouch, tangible interaction, collaboration, cooperation, co-located group work, requirements, user centered design.

1 Introduction

Even though many computerized communication tools exist, there is still a lack of effective tools that support co-located group work. In many situations people fall back on traditional tools such as paper and pen as well as white boards, etc. The strength of these traditional tools is certainly the usability (as the use of the tools is obvious to everyone) as well as the support of workspace awareness (almost everyone can see and understand what the other group members do). Usual PCs are designed for single-user-use and do not support collaborative and social aspects – known as co-located groupware – in an adequate way.

There are new types of computer systems that might add to this. Multitouch technology makes it possible to simultaneously perform multiple actions through a touch-based interface. This offers new ways of providing input that are not present in classical devices such as the keyboard and the mouse. For instance, it allows users to manipulate screen objects using several fingers at once. There is another approach,

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called tangible interaction that enables users to interact with digital information through the physical environment. This is often realized by using physical objects that can be placed and/or moved on a surface. The physical interaction is recognized by the system and results in a manipulation of virtual objects of the graphical user interface. Especially in co-located groupware this new interaction techniques can become a promising addendum as it offers a special quality of awareness – users can see who is going to manipulate information directly. In addition, there is also pen-based interaction which is (still) common on many mobile devices or even tablet-PC's that might add to scenarios of computerized co-located groupware.

In general, the authors believe that multitouch-tables are useful in situations where a group of people physically comes together in order to cooperatively work on a mutual data base while aspects of social interaction is essential to achieve a common goal. These 'new' technologies seem to be promising for co-located group work systems. However, there is a lack of realistic use scenarios showing how to exploit the advantages of these new technologies and its ways of interaction. The aim of this study is to transfer the requirements gathered from user analysis and literature research into concepts and a running prototype in order to testify the solution with real users. Beside this, a catalogue of concrete requirements for the development of co-located group work systems will be presented.

2 Existing Work on Collaborative Group Work

During the last years substantial research on tabletop groupware has been performed providing knowledge about the design and usage of tabletop systems (e.g. see [1]). Many studies are technology focused and evaluate whether and how certain technologies can be used at all. An example for this are studies that deal with 'privacy protection', such as [2] or [3]. They give a pretty good impression how privacy can be protected but they do not consider when the concepts are useful or not. Other studies focus on intergroup development in terms of system interaction concepts, e.g. 'release', 'relocate', 'reorient', 'resize' [4] or 'comprehension', 'coordination' and 'communication' [5]. These studies both provide solid information about human interactions at tabletop systems and prove their results empirically. However, there is a lack of reasonable usage scenarios, which makes it difficult to rate the relevance of results beyond the experimental conditions.

While looking at current studies it could be said that only few studies actually focus on real-life tasks and put them into context. In many cases the kind of interaction, which is tested, is far from current practice and the underlying tasks are basically tailored around the subject of research. As a result, this does not show how technology actually can support human group work in general. In addition to the studies that are more or less technology centered there are pretty good and often-cited studies on general requirements that need to be considered while developing group work. Most of them aim to define basic requirements of group work, which help to understand the basic principles of group work at tabletop systems. Scott et al. [7] define eight general system guidelines for co-located, collaborative work on a tabletop display: 'Support Interpersonal Interactions', 'Support Fluid Transactions

between Activities', 'Support Transitions between Personal and Group Work', 'Support Transitions between Tabletop Collaboration and External Work', 'Support the Use of Physical Objects', 'Provide Shared Access to Physical and Digital Objects', 'Allow flexible User Arrangements', and 'Support Simultaneous User Actions'. Morris adds to these general requirements as she defines three key design challenges, which must be solved by tabletop systems to successfully support group work [8]: 'Integrating Public and Private Information', 'Managing Display Elements', and 'Mediating Group Dynamics'.

In summary, it can be said that there are meaningful general requirements that appear to be a solid basis for the development of co-located collaborative group work systems. However, there are fewer studies that focus on real use cases in order to identify the users needs and transfer them into such systems. However, from a user centered design perspective further requirements will occur while looking on the context of use in real-life situations. Therefore the authors applied interviews and questionnaires in order to transfer the results into a running prototype for evaluation.

3 Proceedings

To develop usable applications that support co-located collaborative group work, it is necessary to analyze the current real-life situation. This is important to understand the context of use and to gather the knowledge needed to design and implement a solution, which fits the users requirements. Therefore a common real-life scenario has been identified, which exists in practice: Today, students very often have to create presentations or reports as a group within the context of university courses. They usually start of with a given topic of their work but they are encouraged to find more deepen information on their own, e.g. through a literature research. This information then must be compiled, combined in new ways, rearranged etc. Usually not all of the work is done in a group. Specific tasks are distributed and performed by members of the group. This not necessarily needs to happen during physical meetings of the group but also separately. However, the results of the work always have a share in the final presentation or the report.

Of course, this scenario is not restricted to students group work. In many other areas of work like research or software development similar situations exists in which a group of persons has to gather information and rework it into a composed result. Thus the authors believe that it will be easy to transfer the experiences to other fields of work. To properly understand the context of use, interviews have been performed with a group of students working on collaborative tasks in a non-IT environment.

3.1 Interviews

Based on the group work scenario of creating a presentation or report interviews have been performed to gather more information on how the group work is done, what is done in group work and what is done alone, which media is used for communication, how the gathered information is assorted and what tools are used.

Six students were interviewed about their experience with group work during their studies. The interview was separated in two parts: The focus of the first part of the interview laid on the organizational part of the group work, like how often they meet, which work is done within the group or which work was done alone. This helped to get a detailed view on how a tabletop system can potentially support the process of group work and which types of tasks are performed during this time. The second part was about the media and artifacts the students use to communicate, especially in the times between their meetings and in which way they organize their information.

As a result it turned out that organizing information, reconciling work results and discussions about results as well as decisions about further actions are generally done as part of the group work. Creating texts, graphics or slides or doing (long-winded) research is done more often individually. This leads to the conclusion that a tabletop system for co-located collaborative group work especially needs to support working with previously created information and less with the creation of many new artifacts. This also means that it must be easily possible to integrate the artifacts created by the individual group members into the group work process. Between the meetings, the students use asynchronous communication, especially email, more often than chat and telephone to communicate with each other. The reason is, that email not only serves as communication medium. Usually additional artifacts are being attached that represent the individual contributions to the group work. This implies, that individual artifacts should be accessible during the group meetings. The common artifacts the interview partners named are tables, lists or plain papers, which must be supported by the system consequently. As a result of the interviews the most important requirements from the use case perspective are as follows: “Provide the ability to exchange objects between users”, “Specialized types of artifacts must be supported”, “Support access to data from asynchronous communication”, “Support merging and distributing of work” and “Favor functions for working with existing artifacts over functions for creating new artifacts”.

The knowledge about the scenario and the details from the interviews result in user requirements that have major impact on the concepts for the final system, which are being described in the next paragraph.

3.2 Concepts and Prototype

The requirements derived from the interviews have been the starting point for general concept ideas of the future system. In addition to the user requirements, general requirements for the development of co-located collaborative group work systems have been taken into account (see section 2). While looking on these requirements and keeping current interaction technologies into account the concepts for the final tabletop groupware system have been developed. As the concepts are very extensive, only a short example is given.

As a result of the interviews it was known, that the users often use plain sheets of paper within the context of the group work. As the system is intended to support the already existing group work process, it needs to reflect this and to provide the users with a paper function, which does not force them to change their typical way of group work. They should be able to draw with pens as they always do. Also paper can be

easily moved to any place, turned in any direction or handed over from one person to another. Consequently these functionalities have been transferred into the concepts. While developing the concept of virtual paper the general requirements have been taken into account. Some of them lead through an extension of the functionality, some were used to backup design decision. For example, concerning the orientation of the paper, it is important to allow the users to freely move and rotate the paper to coordinate their actions, communicate with each other and support the understanding of information [5][9]. This fits perfectly with the results based on the interviews. Other publications add new helpful requirements. Tang et al. [6] found out, that users often switch between more detailed views for individual work and more global views for group work. As a consequence the ability to group and scale the digital paper by simple gestures has been added to the concepts. An additional requirement was to easily be able to switch between different activities during the process, e.g. writing, painting, moving or grouping objects, etc. Thus, we added different types of interaction to give users more flexibility, for example the ability to draw or write using a pen or the fingers (depending on the task and the needed precision). Finally the possibility to create copies of a virtual paper has been added in order to offer more individual access points to the system [10, 11, 12] and to allow the users to move from the closely to more loosely coupled group work [7]. More details can be found in Müller, 2010 [13].

Further concepts, e.g. for a ‘table-sheet’ and ‘check-list’ as specialized types of artifacts as well as generic functions such as a home- and storage-areas have been developed. These concepts all have one in common: They base on the users' needs but add additional necessary functionality based on existing research (compare section 2). The final concepts then were transferred into a running prototype. A self-made interactive table was used that consists of a 55" full HD screen that supports multitouch, digital pens and tangible objects as input for interaction (www.useTable.de). The software was developed in C#. To give the reader an impression, some pictures of the concepts and the final prototype on the useTable are shown in Figure 1 and Figure 2.

Fig. 1. and **Fig. 2.** Drafts of virtual paper, list within a storage area; Prototype running (right)

3.3 Evaluation and Results

In order to evaluate the developed concepts, usability tests with the prototype were conducted. As stated, the goal of this study was to support the group work of students

through the use of a tabletop system. The usability test was limited to one group meeting (as the usual time frame for the groups to solve their task stretches over weeks). Each group had the predefined starting point: A group of students has the task to give a talk concerning software and ergonomics; As a part of their presentation, they want to include which kinds of icons one can distinguish. Therefore they want to show some examples of the three different types of icons 'semi-abstract', 'abstract' and 'symbolic' (e.g. icons for load, save, edit and delete). The participants were provided with some pre-work results they could access during the test to simulate their individual work. This included a classification of different representations for icons. The goal of the group meeting was to create draft versions of the four icons for each of the three types. The task and the duration period (25 mins) were set to offer enough flexibility studying the test persons using the system. There was no specification how the users should proceed to solve the task.

Twelve tests with each two test-persons were conducted, whereas all users studied computer science. At first each group was introduced to the system and got time to explore the functions. After that, they were given their task to accomplish. During the test, the users were observed and notes were taken. The goal was to identify how and which parts of the system were used, and how frequently the participants were communicating and cooperating. After the test, the participants were asked to fill out a questionnaire regarding their personal perception of the systems features and its appropriateness and usability.

The observation of the tests showed that the different groups had very different approaches towards the usage of the systems. Nearly all the implemented features were used but each group had their own combination. Some for example used the background to draw the icons on while others used the virtual paper. The ones who used the paper sometimes used the storage-area-function to organize the artifacts; others just placed them on the center area of the table. In general there occurred very few problems with the usage of the system and most of the discussion was about solving the task. In most cases the icons were drawn cooperatively even though two groups preferred to split the task and work individually. The features provided were considered to be appropriate and easy to use with minor problems concerning text input, which had technical reasons. More details on the test can be found in Müller, 2010 [13].

In general it can be said that the system was accepted by the users and is easily utilized to fulfill the given task. Probably the most interesting result the authors can draw from investigation is that a real-life scenario was found, which could successfully be supported by a specialized tabletop system. This system was created based on user analysis. The resulting user requirements were supplemented with general requirements based on literature and have finally been balanced with technical feasibilities in order to create the overall system. The general requirements turned out to be very useful but are formulated on a very abstract level. To add to this, the authors created an overview of useful requirements for collaborative and co-active group work and append some new ones based on the experience of this study.

Table 1. Overview of concrete requirements for co-active group work systems, mapped to general requirements from Scott et al. [7] and Morris [8]

Focus (Workspace, Artifact, Input)	Interpersonal interactions	Fluid transactions between activities	Transitions betw. pers. and group work	Transitions betw. tabletop collab. & ext. work	Use of physical objects	Shared Access to physical and digital objects	Flexible user arrangements	Simultaneous user actions	Integrating public and private information	Managing display elements	Mediating group dynamics	Provide specialized type of artifacts	Input workspace awareness & ergonomic	Requirement	Short-Description	References
I/W			X											Allow personal as well as group work	Users sometimes switch between personal work and group work. Therefore, the system must be able to support closely coupled work as well as very loosely coupled work.	6
W	X		X											Provide global and detailed perspectives	Closely coupled groups prefer to work on a more global view while single persons prefer a more detailed view.	6
I	X													Provide multiple access points	Every user must have the ability to contribute to the common work and have access to input devices and/or direct input. There must be enough access points to prevent all of them being blocked at one time.	10, 11, 12
I	X							X						Allow parallel input	To enable group members to work loosely coupled, parallel and independent input mechanisms must be provided.	10
I					X									Allow equal access to control for all group members	If there are privileged users in terms of access to control the quality of the group work decreases. Thus all users must be handled equally by their access to control.	10, 14
W					X									Allow equal and open access to information for all group members	If there are users with privileged access to information, the group will tend to ignore this information in their decision-making because of social aspects.	10, 14
A	X										X			Conflicts should be handled by software strategies implemented in software	Whenever conflicts arise, the tabletop-system should solve them automatically in such a way that no human intervention is need.	8, 15, 16
W	X										X			Conflicts should not be handled by software	Conflicts indicate that a closer coordination is needed. Thus it could be harmful for the group process to handle them.	17, 6
I													X	Provide alternative input mechanisms (direct & indirect) depending on the screen size	Direct input may not always be the best solution, especially while using large screens/tables. Consequently indirect input can be more efficient.	15, 16, 18, 19
I													X	Clearly indicate who is modifying (especially when using indirect input)	If the group members cannot easily draw connection between an action and the corresponding actor, the workspace awareness will decrease.	15, 16
W			X											Provide sufficient workspace size allowing the division of private, group and storage territories	In group work situations humans tend to divide their workspace into their personal territories for personal things and personal work, group wide territories for common work and storage territories to store currently not used objects.	20
W	X													Provide visible access to all (private and non-private) territories	Every user must be able to openly view all the other territories because otherwise the group process would be hindered.	20
I		X											X	Attach controls as close as possible to the corresponding territories	Set controls and general the functionality for different territories at the very same place, e.g. put the button for clearing the workspace in the group territory as this affects everybody.	20
A							X			X	X			Support the ability to continuously rotate objects	Humans rotate objects for several reasons. The behavior of the physical objects must be transferred into software.	5, 9
A										X				Provide the ability to exchange objects betw. users	Users must be able to transfer objects between each other.	13
A											X			For direct input, use the function 'relocate' to exchange objects	When objects are exchanged between users, one could use the techniques release, relocate, reorient and resize. Relocate proved to be fastest and least error-prone. Users must be identifiable.	4
A			X								X			Use transparency to avoid interference	When objects are moved, resized etc. they should become partly transparent to minimize interference with other users.	21
A														Objects must be maintained persistent over multiple user sessions	Sometimes users are going to have multiple sessions about the same topic. This makes it necessary to store the state of the workspace between the sessions.	22
W						X			X					Workspace should be totally visible whereas privacy should only be supported, if needed	A transparent workspace is needed to keep everybody in the group at the same level of information, thus privacy can hinder the group process.	20, 23
I	X													Use tangibles as an access point for interaction as they support group work.	Humans are used to work with physical objects, therefore tangibles are a way to support humans in working with a computer and reduce their mental effort in using it.	7
A												X		Specialized types of artifacts must be supported	For task completion humans use specialized types of representation. Adapted types of artifacts should reflect this.	22, 24, 13

Table 1. (*Continued*)

A			X						Support access to data from asynchronous communication	Between the co-located work sessions, the group members will likely communicate via services like email. Provide access to this data during the sessions to harness this data.	13
A			X						Support merging and distributing of work	Meetings are often used, to merge work done by different person or to distribute the tasks among the group members. This means, the system must be able to handle merging work results and distributing tasks + related information.	13
I				X	X				Tangibles are a possible embodiment for a user	Tangibles can be used to easily represent the position of the users on the Table. Each user has a tangible and where ever the tangible is set, the users position is assumed.	13
W			X			X			Tangibles are a way integrate the private data of a user	Tangibles can be used to integrate the private data of a user at the point where the tangible is set on the tabletop computer.	13
A		X						X	Prefer functions for working with existing artifacts over functions for creating new artifacts	Users will likely create the texts, graphics etc. in individual work and during group work they will use this artifacts for discussions or reconcile results.	13

4 Requirements for Collaborative and Co-active Group Work

As part of the research for this study the authors did a lot of requirement engineering to find out how the concepts needs to be designed. The main question was, how to support the users (the students) successfully during their group work (here: creating a presentation or a report). Two sources of requirements were used to define the solution: first, user requirements based on interviews; and second, general requirements based on appropriate publications (compare section 2).

Based on the authors' experiences and as the result of the process and the evaluation it can be said that those general requirements are valid even if (or because of) they are not very strictly formulated. To some kind of degree they offer leeway for interpretation. They worked quite well for the given scenario in this study. However, this study can add to this. Based on the use case those general requirements can be even more substantiated in order to serve as a basis for similar systems to be developed (by other authors). In addition to the general requirements of Scott et al. and Morris two new ones have been created: 'Provide specialized types of artefacts based on common use cases' and 'Input must support workspace awareness and ergonomic needs'.

Furthermore, a supplemental categorization of the requirements has been conducted addressing the typical system-parts, which are: 'Workspace', 'Artifact', and 'Input'. This helps to focus and to distinguish depending on the subject of and context for implementation. In order to prove these even more concrete requirements not only from the practical but also from the theoretical perspective, confirmation in literature has been searched and found. All this information has been consolidated in a condensed overview, which is shown in Table 1. By using this overview, designers and developers will be guided in terms of selecting and translating appropriate requirements for systems that support collaborative and co-active group work. The mapping with general requirements and the categorization therewith help to use this from different perspectives, the theoretical and the practical ones.

Of course, this is not a complete list of requirements but it is a solid base, to be adopted and extended depending on the use case and types of interaction.

5 Summary and Outlook

In this study a user centered approach has been applied in order to develop a co-located group work system. It bases on general requirements derived from literature

research and from task analysis with real users, likewise. A prototype has been developed in order to evaluate: a) the systems usability and b) whether the requirements (especially those based on literature) are fulfilled by the solution.

As a result the requirements were generally fulfilled and the system's features provided were considered to be appropriate and usable. While supporting a real-life scenario the system was accepted by the users and is easily utilized to fulfill the given task. Additionally the authors created a list of requirements for co-located based on the experience of this study. This overview helps designers and developers in selecting and translating appropriate requirements for such systems.

In future the authors will extend the systems functionality based on future user analysis. New concepts for asynchronous and synchronous use cases will be added and the connectivity to web-shared-folders will be implemented in order to provide access to any users' private artifacts. And of course further concrete requirements for co-active group work systems will be developed and evaluated.

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