Supporting Asynchronous Workspace Awareness by Visualizing the Story Evolution in Collaborative Storytelling

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Abstract. Workspace awareness support is mandatory for group support systems. In this paper, we present a novel approach to asynchronous awareness by means of traceability support. We integrate and evaluate our approach in the web portal of CASTing, a tool for audio-based collaborative storytelling. We describe the development of a prototype that visualizes how the collaborative story evolved over time. Our visualization helps group members assess who has modified the shared story, what exactly has been modified and when it has been modified. We evaluate different awareness factors in an experiment. The experiment proved that our visualization approach enables users to acquire workspace awareness by accessing information about previous work of other users.

Keywords: Information visualization, workspace awareness, traceability, collaborative storytelling

1 Introduction

The art of telling stories has a long and venerable history, dating back for centuries. Storytelling is a traditional way to share experience and is mostly oral [1]. Currently,there is an increased demand for audio books [2, 3] and podcasts [4, 5], which indicates arenaissance of listening. This renaissance of listening is also visible in organizations where stories are exchanged face-to-face or via the telephone in order to share knowledge.

Telling stories is not only a human way to share knowledge and experiences, but is also used as a method in different application areas under the designation *storytelling*. Collaborative storytelling aims at the development of a common understanding within a group through coordinated narrating activities, in order to make implicit knowledge explicit [6]. On this basis, audio-based collaborative storytelling uses the act of telling stories in groups in order to enable the exchange of experiences and knowledge within a group. Thereby, audio-based collaborative storytelling provides an alternative to mainly textual techniques, e.g. wikis [7].

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CASTing is a groupware system that supports collaborative audio-based storytelling [6]. CASTing supports users collaboratively creating non-linear stories. Compared, to a linear story with one story thread a non-linear story has several parallelthreads [8]. Non-linear stories are often visualized in a so-called story graph which displays the alternative story threads. In CASTing, a story graph consists of nodes containing audio material and linking edges. CASTing itself consists of two major components: the CASTing client and the CASTing web portal. The client application allows users to create a project team, add audio recordings, segment audio recordings, link audio recordings and select and publish a linear story. With the client users can retrieve the most current version of the story graph and synchronize their local changes. The CASTing web portalallows users to publish podcasts on the Web and discuss, comment, vote and reuse audio-based stories.

In CASTing, users thus mainly collaborate asynchronously in order to create an audio-based story, i.e. users can change the story graph while disconnected and synchronize their changes later on. The resulting asynchronous growth of shared data makes it difficult to trace the story graph evolution. To address this issue, it is necessary to offer asynchronous awareness support [9] and provide users with the necessary data to understand the recent activities in the CASTing system. By providing adequate awareness supports"an understanding of the activities of others, which provides a context for your own activity" [10] can be achieved.

Gutwin et al. [11] distinguish four types of awareness: group-structural awareness, social awareness, informal awareness and workspace awareness. In this paper, we focus on workspace awareness and how workspace awareness can be supported in the CASTing web portal. Workspace awareness is "the up-to-the-moment understanding of another person's interaction with the shared workspace". It is awareness of people and how they interact with the workspace, rather than awareness of the workspace itself [12].

We address the missing workspace awareness in the CASTing web portal with a novel approach on visualizing the story graph evolution which allows users to trace and understand how the current shared state has been achieved, i.e. the visualization displays who changed the story graph, what was changed and when it was changed.

In the following sections,wefirst determine the requirements for such workspace awareness support and the corresponding visualization. Then we discuss related work, and in detail present our solution as well as its integration in CASTing. We further present the setup and results of our evaluation experiment, before we conclude with a summary and outlook on future work directions.

2 Requirements Analysis

In this section, we determine the requirements for supporting awareness within the CASTing web portal. We describe a scenario to state the problem and the hypothesis for this work.

"A group of students at different universities in Germany and USAmade it their business to collect the differences between the educational establishments. For that they want to use CASTing as a tool for audio-based collaborative storytelling. The

group worked successfully for a few weeks on the project, but now they want to widen their circle, so they sent an invitation over the web portal to another person. That person decided to join the project and needs an overview of the events from the last few weeks. He wants to know who is working on the project and how the current story graph has developed over the time."

Whenever people work together in a shared environment (virtual or face-to-face) they need information about the activities and intentions of their co-workers. This information is important for a successful collaboration, especially in groupware systems [10].

Our scenario demands more advancedworkspace awareness. The new group member needs an overview about the recent activities. Within CASTing the story graph captures the current achievement of the collaborating team, as it shows the different alternatives for a story. Users add and remove nodes as well as edges from the story graph. To achieve awareness in relation to these activities, it is necessary to visualize how the story graph developed over time. We base our further requirements analysis on the following hypothesis:

Hypothesis: The visualization of the story graph evolution will enable group members to trace activities in the workspace.

We now analyze requirements for a suitable extension of CASTing based on the above hypothesis. We will evaluate the hypothesis in the evaluation section of our article.

In order to allow users to understand the story graph evolution and thereby provide workspace awareness, the visualization has to provide certain information. According to Gutwin and Greenberg [12], elements of workspace awareness can be divided into two parts: those related to the present and those related to the past. Our scenario focuses on elements of the past, which are action history, artifact history, event history and presence history. These elements of workspace awareness should answer the following questions: *How did an action happen? How did an artifact come to be in this state? When did that action happen? Who was here, and when? What has a person been doing?* When these questions are answered, users are able to identify what happened when, and who made each change. Thereby, users would not only understand how the story graph developed over time, but also who is responsible for the story graph evolution. Thus, the following requirements have to be met:

R1: The visualization of the story graph evolution has to show meta-information which allows users to assess who made any changes, and when those changes were made.

In order to display the meta-information, records have to be kept:

R2: CASTing has to record awareness information once actions take place.

Not every user might be interested in the complete evolution of the story graph. In some cases, users might only have missed a specific time period or might be interested in the changes by a specific group member. This leads to the following requirements:

R3: The visualization of the story graph evolution has to allow users to focus on a specific time period.

R4: The visualization of the story graph evolution has to allow users to focus on a specific group member.

In CASTing, users can select a single thread in the story graph and export this thread as a linear story. Therefore, stories are important artifacts and users might be interested in how this story was constructed:

R5: The visualization of the story graph evolution has to allow users to focus on the development of a linear story.

3 Related Work

In the previous section we identified the requirements for raising awareness regarding asynchronous growth of a story graph.

In this section we consider existing approaches and discuss whether these approaches are suitable to raise awareness regarding the asynchronous growth of the story graph.

Erickson and Laff [13] have added a timeline to the chat environment Babel, in order to better understand the history of a chat conversation. By design, a timeline allows one to focus on specific time periods (R3). In the timeline, each user is represented by a row. Each row displays the activities from all chats of that user, thereby focusing on that user (R4). Tool tips present additional information like the time of contribution and additional information about the user. The timeline enables users to discover when other users are interacting in the collaboration space and it allows users to adjust their working hours so that synchronous collaboration is possible when needed. However, a timeline does not allow users to focus on artifacts like a chat (5).

Virtual School is a collaboration space for student interaction. A user study has revealed that collaboration broke down several times due to lack of activity awareness [14]. One solution was to integrate a timeline into the students` workspace [15]. For each project, the timeline showed different documents. Changes to the documents were represented by the icons on the time axis. To access documents, users were forced to select them in the timeline instead of from a list of documents, making the timeline an integral part of daily work.

User studies [16] have shown that the timeline was of great value to people who were observing the group`s progress. E.g., when there were white areas on the timeline, teachers queried the students responsible for those documents about problems in their group process, and provided help. Here, the timeline allows teachers to focus on projects. However, the timeline does not allow them to focus on pupils across projects (R4).

In both cases, the timeline allows users to focus on two dimensions, the time period and one other dimension like actors or projects.

DreamObjects [17] is a platform for transparently managing shared data of synchronous groupware. It offers flexible and extensible solutions for data distribution, concurrency control, data persistency, latecomer support, and user interface notification. Within

DreamObjects, latecomers can choose between a direct state transfer and a replay of how the current state has been reached [18]. The replay mechanism addresses the collaboration awareness [19] and thus offers a possibility to target the evolution of the story graph through animation. However, in DreamObjects it is not possible to focus on actors (R4) or artifacts (R5).

Facebook offers an activity feed [20], to keep users appraise of the activities of their friends, thereby providing some meta-information (R1). This awareness mechanism allows users to follow actions, but does not offer help in focusing on a particular friend (R4) or activities in a time period (R3).

Apart from the discussed applications, there exist quite a few tools that support users in collaboratively creating stories. TellStory [21] is a collaborative application that supports groups in creating text-based stories. However, no awareness support regarding the growth of the story is provided.

StoryMapper[22] supports groups in telling a story modeled as a conceptual map. Each node in such a map represents an event consisting of facts, the time of the event, and the involved actors and links to related multimedia artifacts. The edges represent semantic relationships between the nodes. The border color of a node is used to indicate who created that node. StoryMapper provides some meta-information (R1) and utilizes color coding to show which user created a node, thereby partially addressing (R4). However, it does not have any mechanism that helps users to focus on time periods (R3) or parts of the story graph (R5).

PhotoStory[23] uses storytelling to increase the awareness in the group about its external presentation but also its social activities. For that purpose, the group can create stories that consist of a series of pictures with corresponding subtitles. PhotoStory uses BSCW [24] as a collaborative workspace. BSCW-specific data structures provide the basis for annotations of the pictures. Apart from story related attributes such as type of event or position of a picture in the drama arc, awareness related attributes like author and creation date are provided. While PhotoStory provides some meta-information about the images (R1), it does not support the users in understanding the evolution of the story by focusing on specific time periods (R3) or users (R4).

The internet-based storytelling application Voicethread[25]supports groups in creating sequences of images or video clips. Users can add textual, audio or video based comments to these multimedia artifacts and hence create a digital story. These comments can be associated with an author through a picture. The comments can be played back in the order of their creation. However, Voicethread does not employ filtering mechanisms for supporting users in understanding the evolution of the story (R3, R4).

The above discussion shows that there is currently no sufficient support for raising awareness of the asynchronous growth of a story graph.

4 Approach

In the CASTing web portal the user cannot keep track of the other users' activities which makes it difficult to stay aware of the changes in the workspace. In our requirements analysis, we identified requirements to improve the workspace awareness by visualizing the story graph evolution. In order to test our hypothesis, we developed and integrated a prototype in the CASTing web portal. The example scenario (Figure 1, Figure 2) was described in Section 2.

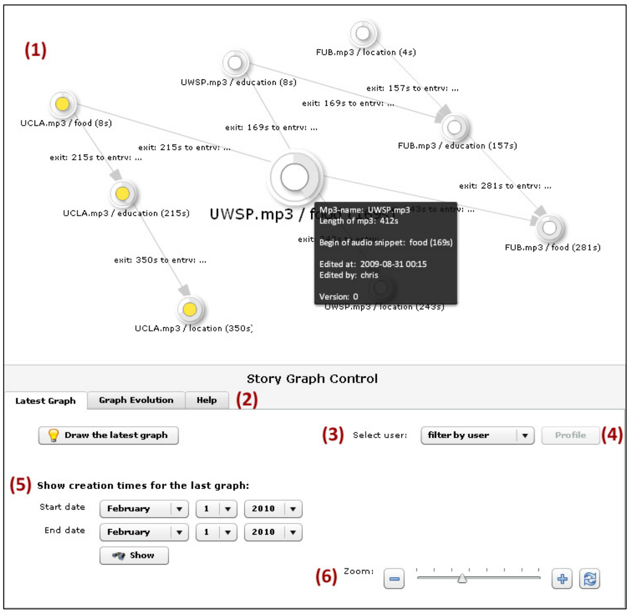


Fig. 1. Story Graph Visualization

The prototype is divided into two main parts (Figure 1). The upper part displays the actual story graph visualization (R1),and the lower part displays the control functions to filter the displayed information in the story graph (R3, R4).

The visualization itself(1) shows a story graph.We picked that kind of visualization, because the story graph is also used in the CASTing desktop application, which is needed by the user for creating the graph collaboratively and asychronously. In this way the users don't get confused. Tool tips provide additional information about the nodesand edges in the visualization (R1).

The story graph control (2) is divided into three parts: Latest Graph, Graph Evolution and Help. The Latest Graph control allows a user to explore who did what and when in the latest story graph, thereby addressing R4. The story graph can be filtered by a user (3), highlighting the edges and the outer rings of the nodes created by the selected user (R4). Thereby, this filter offers the ability to see which person created what artifact in the most current view. In addition,a profile of the selected user is provided (4).

The story graph can also be filtered by creation date of nodes and edges (R3) in the project (5). If a node or an edge was created in the selected time period, these nodes and edges are highlighted (R3). This function offers the ability to see when an artifact was created in the latest graph view. By using this function the question "*When did that action happen?"* is answered for the users.

The Latest Graph control also offers a zoom feature (6) for zooming in and out of the latest story graph. This was implemented to help users when the story graph is larger than the panel on which it is displayed. This allows for the user to take a look at the full graph or have a closer look at specific details. The zoom function is also available in the Graph Evolutioncontrol.

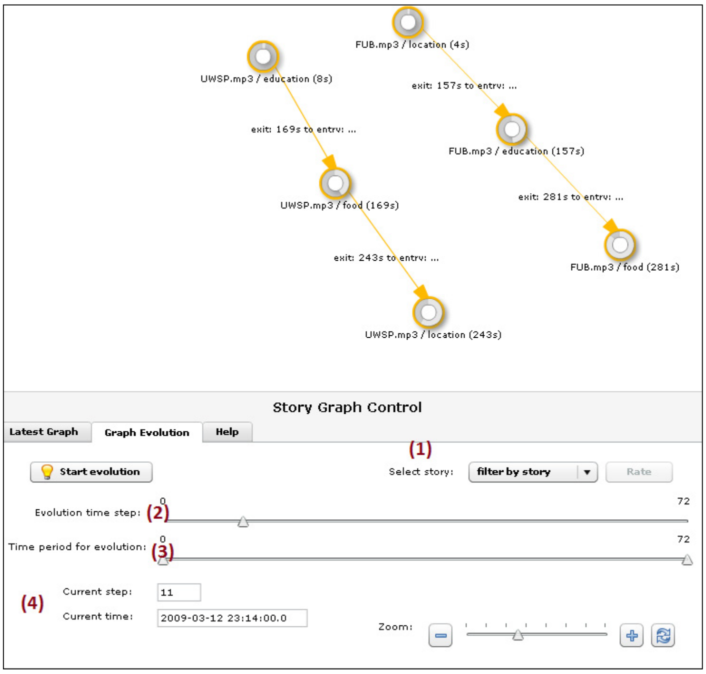


Fig. 2. Story Graph Evolution

The second part of the story graph control is the Graph Evolution (Figure 2). The Graph Evolution control provides several filter functions of all graph artifacts, which were created, modified or deleted over time, and thereby allowing users to understand the evolution of the story graph (R1, R5).

By selecting a story (1), the user filters the story graph evolution in regard to the created stories in the project. If a node or an edge is part of the selected story, then these nodes and edges are highlighted in the story graph. This filter offers the ability to see how the stories in the project were created. Additionally,a user can go directly to the rating of the selected story in the CASTing web portal.

The evolution function allows a user to see how the story graph developed over time (R5).Two sliders allow a user to replay the story evolution. The lower slider (3) allows a user to pre-select a specific time period and the upper slider (2) enables the user to slide through that selected time period. The current slide step and time are displayed in the lower part of the evolution function (4). By using this function the questions "*What has a personbeen doing?*", *"When did that action happen?"* and *"How did an artifact come to be in this state?"* are answered.

The third and last part of the story graph control is the help section (Figure 3).It provides graphical descriptions of the meaning of the colors and displays of a node or an edge, therebyimproving the understanding of the story graph visualization.

The color coding is important for the users to recognize the state of the node and edge preattentively.The inner ring of a node (1) indicates its age, allowing a user to

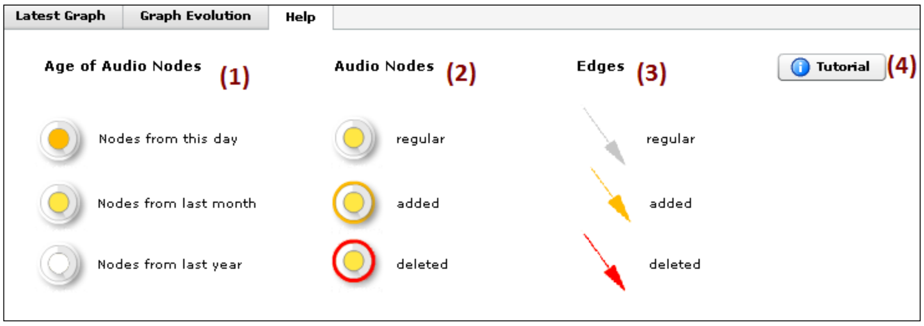


Fig. 3. Help Section

see the approximate age of a node at a glance. If the inner ring is colored orange it was created on that day. If it is yellow then it is at least one month old, and if it is white it is at least one year old. The outer ring of a node (2) is used to indicate the state of the node. If the outer ring of the node is highlighted in orange, the node was created at the chosen point in time. If it is red a user has deleted the node at the chosen point in time. The same color coding is used for edges (3). The help section is meant to be a legend of the story graph evolution, but it also offers a tutorial (4) for new users.

5 System Implementation

Two components were added to the existing CASTing system to implement the visualization of the story graph evolution; an activity log and a service which utilizes the activity log.

An activity log was implemented to record every change to the story graph (R2) in a database used in the StorytellingServer. Information about the kind of change, date and user were gathered. Additionally a service utilizing the activity log to provide information for the visualization and the filter mechanisms was implemented. Both the activity log and the service were integrated into the Storytelling Kernel.

The graph visualization itself and the control sections were provided as a rich internet application (RIA) based on BirdEye[26] and AdobeFlex [27]. BirdEye is a community project to advance the design and development of a comprehensive open source information visualization and visual analytics library for Adobe Flex. The library enables the creation of multi-dimensional data visualization interfaces for the analysis and presentation of information.

6 Evaluation

We conducted a lab experiment to test our hypothesis *"The visualization of the story graph evolution will enable group members to trace activities in the workspace"*.

With regard to this hypothesis (see Requirements Analysis), three questions (I – III) were explored in the experiment, an additional question (IV) relates to the handling of the visualization:

I. Does the visualization make it clear who changed what in the story graph? (R1, R4, R5)

This question supports the *"what"*-category and the *"who"*-category of workspace awareness and in this way advances the workspace awareness in group projects in the web portal.

II. Does the visualization make it clear when something was changed in the story graph? (R1, R3, R5)

This question supports the *"when"*-category and the *"what"*-category of workspace awareness and in this way advances the workspace awareness in group projects in the web portal.

III. Does the visualization make it clear who in general is working in the story graph? Are the users aware of other users in the project? (R4)

This question supports the *"who"*-category and the *"where"*-category of workspace awareness and in this way advances the workspace awareness in group projects in the web portal.

IV. Is the user interface easy to handle?

This question makes sure that the user interface is easy to handle for the project members. If it is easy then the users are able to get all the information they need. So the workspace awareness is advanced in an indirect way.

In the following section we describe the basic setup of the experiment, followed by a presentation of the results. Altogether ten voluntary participants (age 22 to 28; 7 male and 3 female) from four countries (1 from Canada, 5 from Germany, 3 from the Netherlands and the 1from the USA) participated in the experiment. All of them had no experience with the storytelling technique which goes with the basis of the experiment, the scenario "newcomer" mentioned in Section 2. The participants had different experience levels of accomplishing work with the computer. 5 of them had a background in computer science.

Four dummy persons were applied to a project. The employed graph consisted of nine nodes and ten edges and had seven different edit times of the nodes and edges. This equates to a small, but not too complicated storytelling project. That implicates that the study is limited to a small number of users and a small example project.

The execution of the experiment was divided into two phases. In the first phase the participants had to read basic information about storytelling and what they expect to see in the visualization prototype. Doing so should give them basic knowledge for completing the experiment. In the second phase the participants worked with the visualizationand filled out a digital questionnaire at the same time. They were able to complete the experiment independently from each other. It took on average 30 minutes to complete. The questionnaire consisted of two different sections of tasks and a total number of 14 tasks to the experiment. Every task had different answers that the participants were able to choose. The first 12 tasks are closed questions and the last two tasks used an ordinal rating scale to create a ranking. To answer the four questions mentioned above, the following 14 taskswere explored during the experiment:

1. Which persons work on the story graph?
2. What is Nadine's last name?
3. Which person is the most active in regards to the story graph?
4. Which person is the most inactive in regards to the story graph?

Table1. Overview of the relationship between questions, tasks and requirements

Questions	Tasks	Requirements
I. Does the visualization make it clear who changed what in the story graph?	5, 9, 10	**R1:** The visualization of the story graph evolution has to show meta-information which allows users to assess who made any changes, and when those changes were made. **R4:** The visualization of the story graph evolution has to allow users to focus on a specific group member.
II. Does the visualization make it clear when something was changed in the story graph?		**R1:** The visualization of the story graph evolution has to show meta-information which allows users to assess who made any changes, and when those changes were made. **R3:** The visualization of the story graph evolution has to allow users to focus on a specific time period. **R5:** The visualization of the story graph evolution has to allow users to focus on the development of a linear story.
III. Does the visualization make it clear who in general works in the story graph? Are the users aware of other users in the project?	2-8, 10-12	**R4:** The visualization of the story graph evolution has to allow users to focus on a specific group member.
IV. Is the user interface easy to handle?	13, 14	-

5. What did Jared do on January, 27th 2010?
6. Which stories were created in the story graph?
7. Which audio files were used in the project?
8. Which person was the last working on the project?
9. At which point in time was „UCLA.mp3 / location → UWSP.mp3 / location“ deleted?
10. When was node (circle) „UWSP / education” created and by whom?
11. Which person would you contact, if you had questions regarding the UWSP Interview?
12. With which person would you cooperate, if you want to do something with the story "Food Comparison"?
13. The handling of the story graph visualization was easy to learn
14. I always knew where I am and what to do.

In Table 1 is shown an overview about the relationship between the overall questions, the tasks for the participants in the experiment and the requirements in Section 2.

In the following section the questions and the results of the experiment are compared with each other.

I. Does the visualization make it clear who changed what in the story graph? (R1, R4, R5)

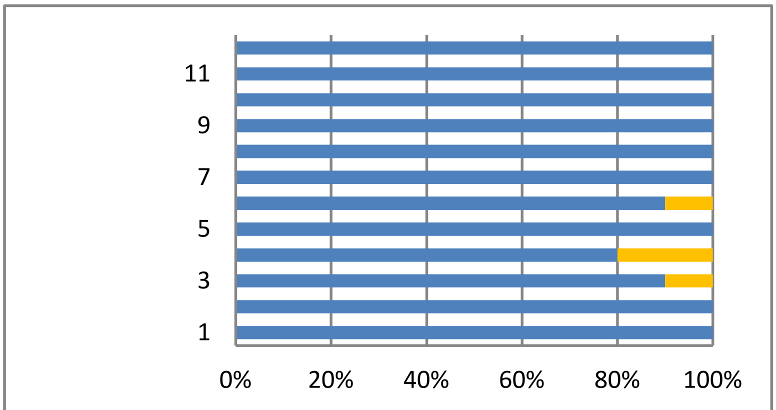
The first 12 tasks, besides task 1 and 9, support question I. All tasks were answered 100% correct, with the exception of task 3, 4 and 6 (Figure 4). Some participants had trouble answeringwhich project member is the most active or inactive related to the story graph. Another participant did not know which stories were created in the project. The issue here might lie in the way the questions were asked. It is possible that there were too many ways to interpret the question. However, most participants were able to solve the tasks. This implies that the visualization of the story graph evolution provides the needed functionality to emphasize the *“what”*-category and the *“who”*-category of workspace awareness and therefore supports our hypothesis.

II. Does the visualization make it clear when something was changed in the story graph? (R1, R3, R5)

The tasks 5, 9 and 10 were answered 100% right by the participants (Figure 4). This implies that the participants were aware when changes to the story graph were made (*“when”*-category of workspace awareness). This also supports our hypothesis.

III. Does the visualization make it clear who in general works in the story graph? Are the users aware of other users in the project? (R4)

Task 1 was answered 100% correct by the participants (Figure 4). This implies that the participants know which people worked on the story graph and in this way they are aware of the other project members. In this way the workspace awareness in group projects in the web portal is advanced. Additionally it empowers project members to be aware of other project members. This, like the two prior results, supports our hypothesis.



	1	2	3	4	5	6	7	8	9	10	11	12
right answers	10	10	9	8	10	9	10	10	10	10	10	10
wrong answers	0	0	1	2	0	1	0	0	0	0	0	0

Fig. 4. Answers of the participants to items 1-12

IV. Is the user interface easy to handle?

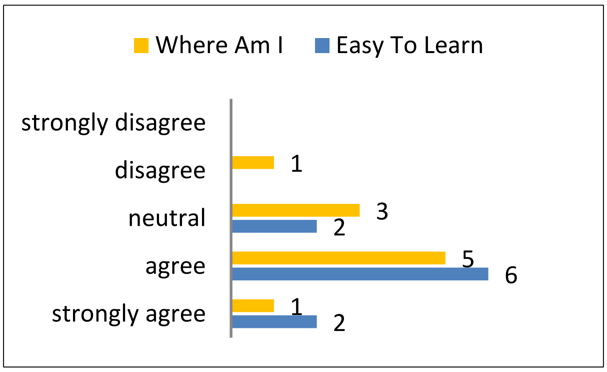


Fig. 5. Answers of the participants to items 13 and 14

The result of the last two tasks of the questionnaire is shown in Figure 5. The participants rated both tasks on average “agree”, which means that the interface and the usability is good, but that there is still room for improvement. A possible explanation for the high variance of the rating is the usage of participants to such applications. The people who had no computer science background rated on average lower than the participants with higher computer science background.

In general it was shown that the visualization prototype provides the functionality to show the user all workspace related information he needs to get an overview about what happened in the past.

The application advances the workspace awareness within the CASTing web portal by showing who edited what artifact in the story graph and when it was edited. It was also shown that the visualization makes users aware of other users within the story graph and the project. This fact and the easy learning of the story graph handling enables users to track the activities of other users and empower users to question and understand the work results of other users.

The experiment has also shown that the visualization contains all the information that was only textually available before. Thus the main goal of the experiment has been achieved.

During the experiment limitations of the prototype were also discovered, which is the basis for improvements in the future. Users were not able to see the entire graph while looking at detailed information. An overview map could be used to tackle this issue. In addition, users were not able to access the audio files represented by the nodes.While the story graph visualization provided awareness regarding changes to the graph itself, awareness support for the evolution of the underlying content is still missing. This is crucial to understand how stories and the meaning they contain evolve over time. Further prospect improvements and extensions for the visualization prototype are discussed in the next section.

7 Conclusion/Future Work

Asynchronously growing story graphs make it difficult for users to trace the evolution of these graphs. Based on the concept of workspace awareness we identified requirements and presented a prototype visualizing the story graph evolution.
Furthermore, we evaluated different awareness factors in an experiment. The experiment showed that our visualization approach enables users to acquire workspace awareness by accessing information about previous work of other users and to follow the development process of the story graph.

The developed visualization could be used to explore its impact on the collaboration between users, e.g.: Does a user need less time to introduce themselves to the project? How big is the difference of workspace awareness in a storytelling web portal with and without the visualization of the story graph evolution? Does the visualization lead to a better coordination and communication between project members? Can a simplification of communication be achieved? How effective is that kind of visualization with much more displayed nodes and edges?

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