The design of t-vote: A tangible tabletop application supporting children's decision making

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ABSTRACT

Children are not necessarily motivated to collaborate if no common ground can be found. In this paper, we present t-vote, a system supporting children's decision making. To encourage collaboration in a museum's context, we employ tangible pawns on a tabletop interface and implicitly script the decision making process of children. We describe the system design, our design process, and rationale.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *user-centered design*

General Terms

Design, Human Factors

Keywords

Interactive tabletops, tangibles, scripting, CSCL, voting, decision making

1. INTRODUCTION

Bringing together heterogeneous groups of children or children who do not know each other's preferences and forcing them to work together can easily overstrain their ability to decide what to do. In this paper, we present an approach for mechanisms to support children's decision making, helping them to find common ground. With t-vote, children express their interest in topics displayed on an interactive tabletop by placing tangible pawns on the topics, while the system calculates the most preferred topics. t-vote provides an alterable, implicitly scripted decision making process which can be scaled into multiple stages of voting, and may employ various voting mechanisms and differently valued pawns for voting.

We first describe the background for our research and illustrate the usage scenario. Then we discuss our iterative design process, and reflect on design choices and insights gained during design, prototyping and development of the t-vote system. Finally, we give an overview on future work.

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2. BACKGROUND

With the invention of tabletop interfaces, new possibilities to support collaborative activities have emerged. In our work we combine the use of tangibles on an interactive tabletop with implicit scripting of decision-making processes.

2.1 Scripting of Collaborative Activities

The notion of scripting is linked to computer supported collaborative learning (CSCL). Engaging young children in collaborative tasks requires a well elaborated blend of hardware, software, content, and mechanisms to guide children though a task [2]. Particularly, scripting of tasks is very important, and this can be through either implicit or explicit scripting of expected collaborative activities. A collaborative script is "a pedagogical scenario that students have to follow when they learn together. […] a script structures the collaboration process e.g. by prescribing different activities […]" [3]. Dillenbourg points out that scripting collaboration is important since free collaboration very often does not lead to the expected results. Moreover, free collaboration can be chaotic and ineffective [3].

To avoid the need to narratively script the collaborative process, i.e. having an adult explain step-by-step what to do or continuously intervene while children work, we are looking for ways to enable children to collaborate and manage a task on their own as much as possible, while still providing them with external structure through a system

2.2 Tabletops and Tangibles in Education and Learning

We designed t-vote for an interactive tabletop, with tangible objects as main means for interaction. Interactive tabletops support social interaction and collaboration by allowing groups to form a circle around them, sharing information and engaging in activities in similar ways to conventional tables. Their horizontal orientation enables more equitable participation in groups [12]. Previous research has demonstrated the value of interactive tabletops to support collaborative learning; a summary of this substantial body is beyond the scope of this short paper.

Due to their small fingers and limited motor control, young children have difficulties working with touch-based tabletops [6]. Controlling tangible pieces, whose tabletop position and orienta-

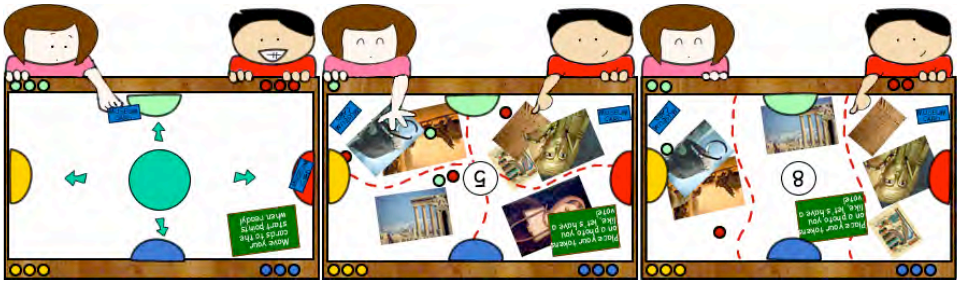

Figure 1. Storyboard. Children move their tickets to initiate voting. The table displays four topics and a timer. Children place their pawns. In the next stage, three topics remain.

tion can be tracked by the technology, has proven to be more successful. Tangibles are easier to manipulate, support awareness of others' actions and collaboration, and are 'fun' to use [1, 8, 13]. Interaction via tangibles may furthermore reduce conflict [9]. We thus chose to implement t-vote as a tangible tabletop interface.

Additionally, tangible pieces are reminiscent of traditional board games that children are familiar with and whose mechanisms match the structured activity we want to promote. Moving tangible pawns is a rather explicit action compared to touching. A number of research projects have investigated the use of tangible-based tabletops to promote collaborative learning (for an overview see e.g. [13]). Most systems allow children to explore a specific phenomenon, which is embodied in the system, such as the physics of light [10], computer programming [5], or warehouse management [4]. In contrast, our project does not focus on a particular subject area, but facilitates groups to choose a joint subject of interest. In that sense, the most related work is WebKit [14], which was designed to allow children to structure and arrange rhetorical arguments that were hyperlinked to information on the Internet.

3. SCENARIO OF USE

t-vote was developed in collaboration with the EU project PuppyIR, which aims to develop interfaces and scenarios to help children seek information in various settings. This includes the use of sharable interfaces to stimulate collaboration. We have set-up a multi-touch tabletop in Museon [15], a children's museum where children can already use barcodes on their museum admission tickets to follow a quest inside the museum. For this quest, terminals with barcode scanners are provided close to different exhibits. Since collaboration is an important aspect in education and many school classes are visiting the museum, the table can be used to form groups and stimulate collaboration. The system is aimed at children aged 5 to 10 (primary school).

t-vote will help children find shared topics of interest and initiate further collaboration. It provides an implicitly scripted collaborative decision making interface. First, while in the museum, children register their interest in topics that an exhibit addresses by scanning their ticket at the exhibit. These topics, for example plant fossils, prehistoric artefacts, or land surveying bookmarked via the tickets, are then brought to the table to search for further information.

Figure 2. Pawn alternatives. Left: Equally weighted pawns may be freely distributed. Middle: Abstract representations of 1st, 2nd and 3rd choice via Gold, Silver, Bronze or numbering were discarded. It is likely that young children will not sufficiently understand this. Right: We settled on using pawns of different size.

To foster team building, in a game based approach at least three "players" are needed to initiate the activity by placing their admission tickets on the table. The table detects markers on the backside of the tickets (using the basic principle of infrared reflection), and identifies the topics associated with these tickets. The system then guides the children through several stages of voting, narrowing down the choices, until only one or two topics are left. Voting is done by placing tangible pawns onto the section of the table associated with a topic (see Figure 1). Topics are illustrated with pictures from the museum's database that remind the children of the exhibit they scanned their ticket at.

When voting is finished, children have thereby agreed on a topic they are all interested in. Next, a search interface with further information on the topic is displayed. This may be material from the museum's database, such as video clips, or information from online sources. As part of PuppyIR, search engines and information filters will be developed to provide information relevant and understandable for children. Alternatively, the system may display advice for re-exploring the museum or on relevant activities.

4. SYSTEM DESIGN AND LESSONS LEARNED

Our system has multiple objectives – it is used by young children, should provide suitable scripting for a voting process, and is mainly interacted with via tangibles. A group should be able to tell the system they are ready to start. We also need a means of making sure the voting process comes to an end, putting some pressure on children to finish while at the same time giving them time to reflect and negotiate.

From the start, our design included identically colored pawns for each 'player', reminding of game play where each player is responsible for his/her own pawns. As pawns carry markers, we can identify whose pawns have been placed, and utilize this information to check whether children e.g. did not place all pawns or placed them all in the same field (which is not allowed). Regarding the weighting of pawns in a vote there are two main alternatives (see Figure 2). The most flexible mechanism would be equally weighted pawns. Alternatively, pawns could represent 1st, 2nd and 3rd choice. One of our core research questions on scripting is how these alternatives perform when working with young children. Furthermore, we decided to limit the number of topics displayed on the table to six. More would be hard to display and could overwhelm children's ability to decide.

The system design started out from the scenario given above, and was iterated via storyboarding and paper prototyping. We are currently finishing implementation of a first working version of t-vote. We here briefly discuss insights from paper prototyping, present the current system design, and then reflect on design considerations and insights gained during the design process.

4.1 Paper Prototyping

To test the design embodied in our storyboard, we performed a small user study with a paper prototype. This resulted in various changes to the design. Paper prototyping has been shown to

Figure 3.a) t-vote paper prototype after first stage of voting. 3.b) User placing pawns on the board

be a particularly effective method for designing tabletop applications [11]. We prepared a paper prototype of t-vote's user interface (see Figure 1), which at this point was still envisioned to include some touch interaction. A main aim of this session was to explore the scripts and mechanisms for voting we had designed. For the test, the game was played once with three adults, once with two older adults, and once with two teenagers aged 11 and 13. They where guided through the game step by step. A facilitator moved the interface elements to simulate system actions. A 2-stage voting process was enacted, using equally weighted pawns.

First, users placed their ticket onto colored semi circular zones on the sides of the board in front of them and pressed a nearby OK icon to signify they were ready. Randomly selected photos were arranged on the table by topic, and 'boundary' string was placed to separate the board into partitions. Users were informed they could place colored paper scraps (in the same colour as the card-holding zones) inside partitions to vote for topics they wished to discuss. After the first vote, topics that received no votes were ruled out and partitions were rearranged by the facilitator. Then, participants were told to vote again and to agree on one or two topics, so they could have a discussion on the topic(s) they wanted to learn about most. Finally, photos and information on the winner(s) were shown. This process led to several observations:

- When trying out the game with only two users, we realized that the system could not detect how many players were present and that it needed a mechanism to determine whether players are ready to start or whether another player was about to join.

- Equally weighted pawns were problematic. Participants were not sure whether they had to place all of them and when told they had to, the children placed all of them on one topic instead of distributing them. This almost always resulted in a tiebreak scenario, especially with more than two players.

- It was unclear how to resolve a tie if users could not come to a decision. Equally weighted pawns made tiebreaks more likely, and the game went on for a long time.

4.2 System Walkthrough of the Working Prototype

The table displays a message, asking the children to place their admission tickets on the table. When two tickets are placed, a timer starts, waiting for a maximum of another two tickets. When either the timer expires, or four tickets are placed on the table, the voting starts. The children are asked to move their tickets into the color-coded half-circles at the edges of the table (Figure 4, left) to signify they are ready. This makes sure that the central space of the table is available for voting. When all tickets have been moved, voting can start. Colored pawns in different sizes are lined up on the sides of the table, to be used for voting.

Up to six of the most popular topics bookmarked via the tickets are laid out on the board within clearly outlined sections. Each section displays pictures related to the topic. Children are instructed to place their pawns, representing 1st, 2nd and 3rd choice, represented by pawn height, onto topics they want to discuss (Figure 4). A new timer appears. When it runs out, the voting closes. If a child has not placed all pawns by then, the system may start a second, but shorter timer and requests to place missing pawns. The system calculates the result of the vote and eliminates topics without votes and with low numbers of votes. The surface then displays a message to remove the pawns, and shows flashing circles around pawns as additional trigger to clear the surface. In the next round, the remaining topics are displayed. This is iterated until only one topic remains, or until two successive attempts to decide on the two last remaining topics are unsuccessful. The display now fills with information on the winning topic(s).

4.3 Design Issues and Considerations

Initially we anticipated that equally weighted pawns would be easier to understand for younger children, requiring less abstract thinking. One of the core insights from the paper prototyping process was that this would not work with children who would want to make their topic win and place all pawns in one area. This is an interesting trade-off. The cognitively simpler mechanism entices competitive behavior, interfering with negotiation. The system therefore now has differently sized pawns for 1st, 2nd, and 3rd choice. This encourages children to distribute their vote, strengthening our scripting approach. In addition to reducing the likelihood of ties, it also reduces the number of pawns needed to express preferences.

In our initial scenarios, we had imagined using a mix of touch and tangible interaction. Children on arrival would place their tickets at the border of the table, and would touch an OK button next to the ticket to indicate they were ready to start voting. Once all children had done this, the

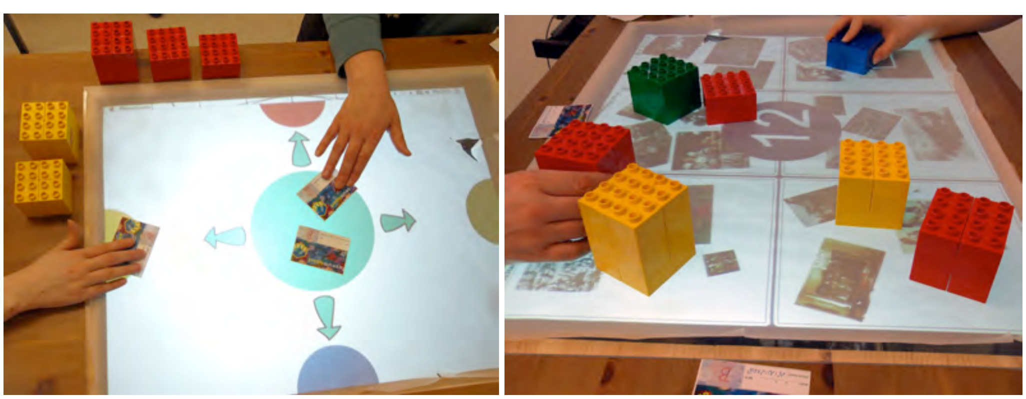

Figure 4. Software prototype on the table. Left: moving tickets into personal zone to start. Right: voting with pawns of different size indicating 1st, 2nd and 3rd choices. Each player has one color.

vote would start. But given children's tendency to tap any button-like objects on a touchscreen and to disrespect other children's territory [8,9], we realized this wasn't viable. As the table is located in an open area, other children might even reach over and touch the table, interfering with the game. Furthermore, the paper prototyping session had revealed that the system would need to determine whether all children involved are ready to start (or whether they are waiting for somebody). Our current design thus has the children first place their tickets anywhere on the table. When a user is ready they slide their card into a personal semi-circle area, which appears after more than two users have placed their cards to guarantee that at least three children are participating. The vote starts once all tickets have been moved into the semi-circles, which have the same color as the pawns. Overall, our design has moved from touch interaction to more explicit physical actions to create explicit transitions.

Another issue revealed in the paper prototyping session was how the system would know a vote was finished. On the one hand, children should be able to assess the outcome of a vote and to change their minds while negotiating. The system thus cannot simply wait until all pawns are placed. On the other hand, some pressure is needed to prevent children from taking too long. We explored several solutions, including the use of individual 'OK' buttons per player, which were discarded as too volatile to being pressed prematurely and enabling one child to effectively veto the outcome of a vote. We decided to use a simple timer that would count down.

In the future, additional notifications inside the game will further stimulate discussion amongst children as to what topics are the most interesting. We will also aim to display multiple instances of text messages, facing in different directions to ensure there is no directionality to using the table, and replace these with images where feasible. To minimize chances of a tie, the game may end with either one or two topics being chosen. Once there are only two topics left, the system allows for one more iteration of voting. If children at this stage do not agree on one topic, we have to assume that they are not willing to change their mind.

Finally, tangible interaction in the case of our system brings several benefits, but also comes at a price. We found that the pawns provide us with valuable information (on where each child has placed which pawns) that would be hard to attain using touch interaction. They are more explicit for interaction, increasing the likelihood that children adhere to the rules. But a main disadvantage of tangibles is their immutability – with a multi-stage vote, pawns need to be cleared off the surface before the next stage of voting can begin. During initial storyboarding, we had not realized the need for an interim phase that asks children to remove pawns. In sketching we depict system states, but with tangibles we need to think more about transitions and manual interactions. This highlights the importance of physical prototyping and simulation of the interaction when designing tangible interfaces.

5. OUTLOOK AND FUTURE WORK

Here we have described our current system design of tangible scripting for a voting process and discussed our design considerations. We are now finishing the implementation of a first working version, which will undergo further user testing.

For the final system, the design requires further refinement, for example more sophisticated rules on how to determine which topics to remove in each step of voting (sometimes, four topics might receive a low amount of votes, while the highest only has a slightly larger number of votes), and whether to ignore the 3rd choice pawn once there are only three topics. We plan to test our system in the museum space, investigating how well design solutions such as the use of a timer work with children, and whether the implicit scripting is successful in supporting decision processes. After running a usability study with t-vote, results and design ideas will be incorporated into a museum demonstrator that will be part of the PuppyIR project results, and will be installed on the table so it is usable even after the project ends.

6. ACKNOWLEDGMENTS

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