Utilizing Digital Tabletops in Collocated Agile Planning Meetings

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Abstract

In agile software development, planning meetings play a pivotal role in establishing a concrete understanding of customers' requirements. Using tools to enhance the effectiveness of the planning meetings without affecting the agility of the practices or disturbing the traditional settings is a challenging task. In this paper, we propose the use of digital tabletops as a means of collaboration in agile planning meetings for collocated teams. To support this proposal, we introduce Agile Planner for Digital Tabletops, a planning tool that was specifically designed for use on large horizontal displays. A multipart study involving a variety of qualitative methodologies was conducted to evaluate this approach. The study involved 14 individual participants plus a five member agile team. The individual evaluation suggested that in general, the tool is usable with minor issues to be considered in future design revisions. The agile team evaluation revealed a significant interest in the tool and its added benefits to the agility of the planning meeting with some issues to be further enhanced.

1. Introduction

Synchronous planning meetings are an essential group activity in agile teams. They involve both software developers and customers [1] and are held before the beginning of a new iteration. In a planning meeting, software developers and business stakeholders sit together to retrospectively look at the past iteration and collaboratively plan for a new one. In a traditional agile planning meeting, participants usually sit around a table, define tasks and concisely describe them on index cards. Index cards are spread on the table and participants can use their hands to manipulate them. Manipulation of cards involves editing a card, moving a card to a new position, rotating a card towards others, logically grouping cards into piles, and trashing dispensable ones.

Agile planning meetings constitute a set of connected milestones in the evolution of the software under development. Therefore, a planning meeting is often based on the scenarios and contexts of previous meetings, and in turn is considered the basis for the following planning meeting. For this reason, at the end of the planning meeting, participants collect the cards and keep them for use in coming iterations. This seemed to be a flawless process until practitioners started to realize the importance carried in the semantic and contextual information in the spatial organization of these cards on the table. These implicit pieces of information can be as important as explicitly documented information because they imply priorities, timelines and impact. Thus, when index cards are collected at the end of the meeting, the probability of losing the implicit knowledge attached to these cards is high.

In our laboratory, we have developed several systems in an attempt to support planning meetings without negatively impacting their agility [2]. While the focus of these systems was mainly to provide solutions for distributed settings, these systems were also used in collocated settings. It turned out that using existing tools in collocated meetings broke the natural interactions of the team: the team member controlling the mouse and keyboard became a bottleneck in creating and manipulating story cards. In collocated meetings, participants are used to sitting together in one room and collaborating to reach decisions using a shared interface as a means of collaboration. Using agile planning tools, to share the view amongst all participants, the user interface of the tool has to be shared using a projector on a vertical wall. As a result, participants will have to be seated in a way that allows everyone to comfortably look at the vertical display. This necessarily means that the traditional round table setting will be distorted resulting in a less face to face communication which is very crucial to agile practitioners [3].

Therefore, introducing a computerized way to support collocated planning meetings is not straightforward. Any suggested solution needs to provide not only (1) an added benefit to the traditional practice but also (2) a guarantee that essential settings, activities and practices are all supported and are in no way distorted. A violation to the first requirement makes the solution economically unjustifiable; whereas a violation to the second requirement makes the solution impractical.

Taking these requirements into consideration, we suggested the use of digital tabletops in agile planning meetings [4]. We developed an agile planning tool especially for use on digital tabletops as will be detailed later. Agile Planner for Digital Tabletops (APDT) is a solution that addresses the two previously mentioned requirements. We started to use the system for our own planning meetings in the lab. It was fairly easy to determine that the first criterion was met by looking at the advantages the electronic tool provided such as the ability to store and retrieve projects and the ability to share information across different locations (e.g. making it available for telecommuters). However, it was not as easy to determine whether the second criterion was met or not. We were not interested in determining whether utilizing a digital tabletop is superior to the traditional way of conducting planning meetings, but rather we needed to know to what extent the suggested solution preserved or disturbed the original practices of agile teams in their planning meetings. For example, how is the collaboration amongst participants affected by the new tool? Does the tool encourage interaction? Or does it intimidate communication? Do participants feel more or less comfortable when dealing with electronic as opposed to paper artifacts? Is there anything participants usually do in their traditional meetings but cannot do anymore using this tool?

In order to systematically investigate these issues, we conducted a series of qualitative studies in our laboratory over a two month period. In this paper, we present an overview of our new tool as well as an evaluation of this tool.

After a review of related work in Section 2, the paper provides an overview of APDT in Section 3. Then Section 4 discusses the study conducted to evaluate the tool, and finally we present an analysis of our findings in Section 5.

2. Related Work

2.1 Digital Tabletops

Tabletop technology has been widely applied to education [5, 6], computer games [7, 8] and art design [9]. Outside our own work, it has not yet been utilized for software planning meetings. Research in other application domains, however, is encouraging. For example, Döring [5] explored the application of digital tabletop in art history research and education. Despite the differences between this domain and software planning, his findings can still be relevant to the kind of tools we are building. His case study indicated that the tabletop tangible interface integrates the advantage of digital representation with approved traditional paper based art education. Also, Magerkurth et al [7] developed a tabletop based gaming platform to augment the strength of traditional board games. They pointed out that the digital tabletop provides rich gaming experiences impossible to realize with traditional board games.

Furthermore, a large body of research is focused on understanding the natural interaction that people practice when collaborating around a tabletop. For instance, a study was conducted by [10] to find out whether cooperative gestures can be used to enhance a user's sense of team work. Also, [11] studied the roles of "territoriality and orientation" in distributed collaborative tabletop workspaces. Another area of research in this field highlights the technical issues faced when using a tabletop as a means of conducting collaborative activities. As an example, the usage of interaction devices in collocated collaborative work settings at a tabletop display was investigated [12]. Moreover, [13] presented selection techniques for multi-touch screens to smoothen the interaction with the tabletop surface. Kruger et al [14] introduced an algorithm called RNT to provide better support for orientation of the digital artifacts on horizontal displays. In the tool presented in this paper, we use the RNT algorithm to implement rotation and translation features.

2.2 Agile Planning Solutions

As a pivotal collaborative process, agile planning has been paid special attention academically and commercially. There have been a considerable number of attempts to figure out what methods and tools best support agile planning processes without sacrificing communication amongst the development team and the business stakeholders. For example, [15] suggested the use of lightweight methods such as whiteboards but asserted that such methods are only useful when the customer is onsite. ExtremePlanner [16] was thus introduced as a more convenient tool for agile planning in distributed settings. Other web-based tools including Rally [17], XPSwiki [18], TargetProcess [19] and ScrumWorks [20] were developed to enhance the planning process but without explicit consideration of horizontal displays as a means of conducting collaborative activities. Also, most of these tools and other commercial products focused on delivering the functionalities that were very likely to be needed in a planning meeting, but introduced a gap between what the traditional practice was and how the agile team needed to interact with such tools. For instance, the visualization of index cards as information holders was overlooked in many planning tools. Even when this problem was resolved in tools like CardMeeting [21], users were expected to provide input through electronic input devices, namely

mice and keyboards. Support for handwriting input was often absent.

DAP [22] was developed as a Java-based multi-client agile planning tool specifically designed for synchronous distributed meetings. This tool provided a digital environment for Agile planning that is suitable for presentation on digital tabletops while preserving the benefits of card-based planning. DAP has been used in our lab as a planning tool for our daily scrums as well as our release planning meetings. After an initial excitement about using the tool, usability issues started to arise and collaborators informally expressed dissatisfaction when using DAP on our digital table. Although DAP intended to provide support for horizontal displays, it showed issues supporting relatively large tabletops such as the one we have in the lab. This was mainly because of the use of typical widgets such as fixed menus and toolbars. Beside that it did not properly scale and orient artifacts and fonts. The accuracy of the touch on the surface was also a problem: mouse pointers are more accurately positioned on a display than fingertips. Moreover, DAP supported handwriting input only from handheld devices which increased hardware requirements of the tool as well as the intuitiveness of the interaction. Although DAP supported moving and grouping story cards, there was no support for reorientation or tossing of objects. Due to these limitations and usability issues, there was a need to develop another tool especially for use on digital tabletops. The following section provides an overview of our newly developed Agile Planner for Digital Tabletops (APDT).

3. Overview of APDT

3.1 Agile Planner for Digital Tabletops (APDT)

APDT is a planning tool that was specifically developed for use on large horizontal, touch sensitive displays. The ultimate goal of APDT is to support the agile planning meetings by making the interaction with the planning objects feel as close to interacting with real paper cards as possible, and enhance this interaction by utilizing the advantageous features of electronic devices.[1] The design of story cards in APDT meets the critical aspects defined by Jeffries [23]: "Card, Conversation, and Confirmation."

3.2 Implementation

APDT is a multi-user, touch sensitive, handwriting and speech enabled planning tool. This tool was developed using Windows Presentation Foundation available in .Net framework [24]. The tool supports gesture recognition, translation and tossing of objects as well as single touch free rotation. Different libraries were utilized to develop and integrate features like handwriting and speech recognition. APDT uses a DViT-based digital tabletop [25] that consists of eight 19-inch 10 mega pixels LCD screens as shown in Figure 1. The table surface is 100cm wide by 240cm long and can support up to 12 collaborators.

Figure 1 - Digital tabletop surface

APDT allows for a multimodal interaction with the digital tabletop. Besides being able to use traditional input devices like mice and keyboards, users can use finger tips, electronic markers and even their voices to interact with the tabletop. The multimodal interaction support in this tool includes: 1) pointer events such as translation and rotation, 2) gesturing, 3) handwriting recognition, and 4) speech recognition.

3.2.1 Translation & Rotation

The new feature set of the .NET framework allows for unrestricted 360° rotation and movement of virtually any UI widget including basic items such as textboxes, buttons and labels. Using the RNT algorithm [14] implemented for APDT, users can manipulate the location and orientation of artifacts in the workspace using their fingers. RNT allows users to move and rotate an object with a single mouse move.

Furthermore, the size of the table makes it impossible for every user to reach every region of the table. Thus, the implementation of a tossing function allows for 'throwing' objects across the table to meet participants that are out of physical reach.

3.2.2 Gesture Support

The size of the table and the varying positions of the different users may cause ordinary interfaces like menus or toolbars to be inconvenient. To create an orientation-independent environment, gesturing was implemented for the creation and deletion of planning objects which makes the use of buttons and menus un-

[1] A longer term goal is to integrate DAP with APDT to support table-based distributed planning.

necessary. Simple gestures that allow for an identification of the user's position relative to the table provides for the ability to create new cards 'the right way up.' That is, they appear properly oriented towards their creator.

3.2.3 Handwriting Support

Unlike some previously discussed tools that depend on external devices to feed recognized handwriting as input to the tabletop, APDT integrates the handwriting recognition functionality directly into the table-interaction. Unfortunately, the DViT provides a very low input resolution compared to that of the stylus used on a Tablet- or Pocket-PC. To overcome this limitation, cards are enlarged on demand so that users can write on them as they would on a whiteboard. They then go back to their normal scale when the user finishes writing. Collected handwriting strokes are analyzed by a handwriting recognition engine provided by Microsoft. As a result, handwriting strokes will be converted to text, numbers and other computer readable data formats. The original handwriting and the recognized text are both displayed and stored as shown in Figure 2, and can be edited afterwards.

Figure 2 - Handwriting recognition

3. 2.4 Speech Recognition

Speech recognition is an additional input method that APDT supports in order to resolve the distance and orientation problems associated with large digital tabletops. Utilizing the .NET speech recognition engine made it possible to support voice commands as an alternative channel for user input without the need to touch the tabletop surface. APDT currently supports a basic set of voice commands to create, delete and select artefacts.

3.3 APDT Feature Set

Participants can interact with the system through the multimodal input system (i.e. touch, gestures, handwriting and voice) to create story cards, modify their contents, color them, resize them, move them on the surface, toss them to each other, rotate them for collaborators on other sides of the table, group them into iterations, undo and redo actions, and delete unused artifacts. Upon every action, the status of the project is automatically persisted on a server so that it can be retrieved on demand or shared in distributed settings. The choice of this feature set was based on what we observed to be the most common activities in a planning meeting. Table 1(overleaf) lists these activities along with the way they are conducted in both the traditional way and using APDT.

4. Evaluation

We conducted a study to evaluate how practical it is to utilize Agile Planner for Digital Tabletops in collocated agile planning meetings. In this context, we define practicality as the ability of the tool to effectively and conveniently provide an added benefit to the planning meeting without compromising or distorting any of the traditional activities and practices. Based on this definition, practicality can be seen to encompass or imply other quality attributes such as usefulness and convenience. This was the main focus of our evaluation. We wanted to know how useful this tool can be and whether users will perceive it as convenient. However, when we first started to think about a possible approach to evaluate the system based on these measures, we came across an important issue. When observing an agile team using the system, we realized that there are some usability issues that may directly influence the usefulness of the tool or/and the perception of the users. Thus, we wanted to mitigate the effect of this factor in our study by (1) fixing major usability issues before the actual evaluation, and (2) conducting a separate usability test to isolate remaining usability issues. As a result, we conducted two different evaluations: the first was an evaluation focused on usability issues and whose subjects are individuals, and the second was a group evaluation to study the usefulness of the tool in agile planning contexts. Combining the results of both evaluations, we wanted to shed light on the following:

a. Platform Usability: Are there any usability issues in APDT that make it hard to use in a collocated agile planning meeting? What should be improved to provide a more convenient environment for agile practitioners?
b. Natural Behavior: How are natural behaviors in traditional agile planning meetings influenced when using APDT? Does APDT provide a feature set that meets the expectations and needs of collaborators in agile planning meetings?
c. User Preference: How do collaborators perceive APDT? Do they prefer to use it in some contexts but not others? If they had the choice, would they choose this tool over the traditional pen-and-paper? What factors impact their preferences?

Table 1 - Feature set of APDT covering common activities in agile planning meetings

Core Activity	Pen & Paper based planning	Tabletop based agile planning (APDT)	Feature Group
Create card	Fetch a new paper card and put it on the table.	Use finger tip or pen to create a new index card at the location of the gesture.	Gesture Support
Move card	Hold the card and put it on the target position.	Use a finger tip to press the card, make the card move with the finger to a target position.	
Toss card	Throw the card on the table surface or pass it from hand to hand.	Use a finger tip to swipe the card, and toss it to the target direction.	
Delete card	Trash the card.	Make gesture on top of the target card.	
Resize card	Undoable unless other card decks are available with different dimensions. If available, rewrite card contents on a new one.	Drag the bottom right corner of target card.	
Undo/ Redo	Depends on the operation (e.g. wipe the card contents out and write it again).	Use gesture to undo/redo last changes.	
Select card	Point to/Pick up the target card.	Touch the card with finger tip.	
Save cards	Collect cards and probably take a picture for the table surface.	Project automatically persisted.	
Change color	Undoable unless cards with different colors are available. If available, rewrite card contents on a new one.	Use finger tip to click relevant color on Control Panel.	
Add contents	Write on the card with a pen.	Use finger tip or electronic pen to write/erase handwritings on the card. The handwritings will be converted to text by handwriting recognition engine.	Handwriting Recognition
Voice control	N/A	Use speech to create/delete/select cards.	Voice Recognition

4.1 Usability Evaluation

Goal

This part of the study has two main goals: (1) to find major usability issues before the actual group evaluation, and (2) to separate the influences of usability problems from the practicality of the tool.

Methodology

The individual usability evaluation (experiment) consisted of a sequence of activities:

Briefing. Before the evaluation session started, the experimenter provided a three minute concise description of the tool and the terminologies that the participant might encounter during the experiment such as "story card" and "iteration." Starting up the application on the tabletop to be ready for evaluation was intentionally delayed till the participant arrived at the lab. The reason behind this was to implicitly give the participant a clue on how to apply touches on the digital surface.

Pre-Questionnaire. Prior to conducting any activity on the tool, participants were asked to fill questionnaires to collect information about their familiarity with planning tools in general, agile methods as a concept, touch-sensitive devices and digital surfaces. This questionnaire aimed to understand the effects of these factors on the performance of our participants to help extract unbiased conclusions.

Task-Centered Walkthrough. Due to the fact that we were testing an electronic planning tool, it was unfair to expect participants to know in advance what they can do or how they can interact with such a tool. Also, we wanted to insure sufficient coverage of the main feature set of interest to us in this individual evaluation. Thus, we did not want the participants to randomly drop in and play with the tool (which can be an option for other applications). We conducted a task-centered walkthrough [26] which provided a set of tutorial tasks for participants to use the tool. The tutorial was a single page script that consisted of 15 clearly numbered tasks like these ones:

a. Create a story card with your finger touch.
b. Pass the card to the tester opposite to you.

The tasks were carefully designed to cover the following aspects:

1. The interface design of the tool.
2. Learnability (how quick the user can learn a certain aspect with minimal help).

3. Usability of gestures.
4. Accuracy of handwriting and speech recognition.
5. System performance.

For complex tasks, some hints were given at the bottom of the task sheet to give the user a starting point on the task. These instructions were worded carefully to provide the least amount of help and let the participants depend on themselves to figure out the rest. An example instruction that was attached with task (b) in the previous list is:

The card can be tossed on the surface of the screen.

Along with the task sheet, the participants were also provided with an instruction sheet with the gestures and voice control commands that the tool supports. This instruction sheet is a screenshot of the help window our tool provides for the users, part of which is shown in Figure 3.

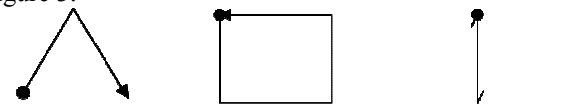

Figure 3 - Part of the help on gesture support

Observation. An essential part of the individual evaluation was observing participants while performing the tasks. We were interested in participant's thoughts, behaviors, reactions and comments. The duration of the test was also recorded. The participants were encouraged to "think aloud" while doing the tasks. That is, they were asked to speak out what they wanted to do and how they intended to do it. They were also encouraged to ask questions whenever they needed; however, the observers used caution when providing answers to make sure not to bias the subject's perceptions.

Post-Questionnaire. At the end of the evaluation, participants were provided with a questionnaire to collect information on how they perceived the tool. The questionnaire consisted of Likert-scale questions as well as open ended questions to give the participants a chance to express their opinions.

Informal Interview. Some participants who were observed to have difficulty or that took a relatively long time to finish the tasks were informally interviewed for no more than 10 minutes to get more information on what was hindering their performance.

Participants

The individual study involved 14 participants; all were graduate students in computer science. Participation was voluntary. Evaluation sessions were scheduled at the convenience of both the participants and the observers. Participants were asked to come to our lab at different times to individually conduct the evaluation to avoid any learning effects among subjects. Each participant was given the choice to stand on any side of the tabletop; whereas the observer stood on the opposite side.

Based on the pre-questionnaire participants were given prior to the evaluation, 9 subjects had a general idea about agile methods. Three of which had actually used agile methods to develop software applications.

Regarding knowledge on digital surfaces, 7 out of the 14 subjects had seen digital surfaces before, mainly on TV or on the Internet. Four of which had used a tabletop once or twice. Moreover, 10 subjects had used other touch sensitive devices such as tablet-PC's and SMART boards.

Study Implementation

Pilot Study

The usability evaluation started up with a *pilot study*. The pilot study had two main objectives: (1) to give early insight on the design of the study in general, and (2) to discover major usability issues and fix them before conducting the rest of the individual study and the group study.

The pilot study involved 5 randomly selected subjects. These subjects underwent a procedure similar to the one explained in the methodology section. The outcome of the pilot study encompassed (1) a set of major usability problems and bugs to be fixed, (2) suggestions to improve the task list and related instructions, and (3) possible improvements to the questionnaires. Usability issues were mainly observed in tasks like deleting artifacts with gestures (although was ranked *easy* by the participants, they needed many trials to get it right) and resizing artifacts using finger touch. Also, some usability problems were related to performance issues that resulted in a slow reaction from the tool to the users' commands. Moreover, a general usability issue was the over-sensitivity or inaccuracy of the digital surface reaction to the users' touch. Figure 4 shows the results of the pilot study. The number in the circle indicates how many participants rated the task at a certain level of easiness. For example, the number of participants who thought "*using help*" was an *average* task is *3*.

After the pilot study, we resolved performance and usability issues and fixed some bugs. We increased the size of controls to offset the position error caused by the inaccuracy of the finger touch. Also, we changed the design of the tool so that it does not require many single touches to perform operations on artifacts. To

solve the deletion gesture issue, a delete button on the corner of the artifact was added. We also provided a larger handwriting enabled space in response to the evaluator's comments.

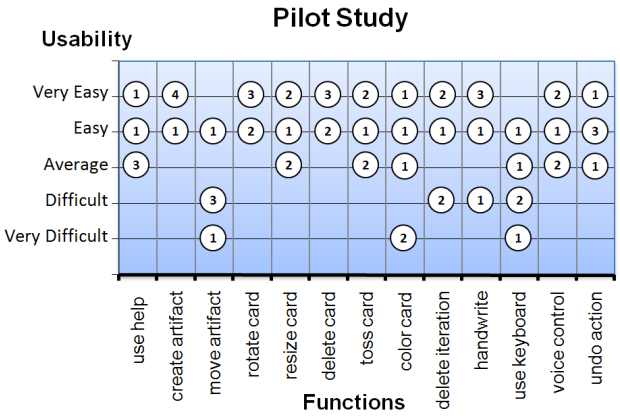

Figure 4 - Pilot study results

The pre- and post- questionnaires were both refined iteratively to provide more reliable and valid question items. Furthermore, the wording of some tasks was modified and the help document and the instruction set were changed accordingly.

Formal Evaluation

The formal evaluation was conducted immediately after finishing the changes resulting from the pilot study. In this evaluation, 9 subjects were required to undergo the refined procedure and fill out the questionnaires. Some participants were also interviewed.

Results

Figure 5 shows the questionnaire results the same way as in Figure 4. Compared to the initial results from the pilot study, the formal evaluation clearly reveals a better usability of APDT. It is noticeable that participants' votes are highly concentrated above the average level of easiness except for the handwriting feature.

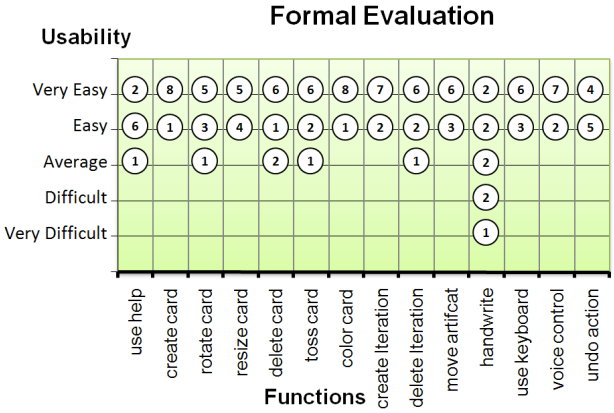

Figure 5 - Formal evaluation results

The average time of completion for all tasks decreased from 11 minutes in the pilot study down to 6 minutes (almost half) in the formal evaluation. Most of the tasks were perceived as easy. Deleting and resizing artifacts were no longer usability problems. Nevertheless, three participants showed their dissatisfaction with the handwriting functionality. The informal interviews with them revealed that they felt the handwriting on tabletop is too thick and hard to recognize.

According to our observations, in the pilot study, the participants asked on average 1 question per subject - questions like: *"How can I do that?", "Why does not this work?", "Is it right to do it like this?"*. In the formal evaluation; however, only 3 similar questions were asked by all participants.

In the pilot study, we noticed that participants valued various features differently. Particular instances included participants preferring to use handwriting as opposed to typing on keyboard and vice versa. Another instance of diversion involved some participants valuing gestures over voice commands while others thought voice commands are more valuable than gestures. In the formal evaluation, we added some questions to clarify these preferences. The results show that 4 of 9 testers prefer gestures while others prefer voice control. Only 3 participants prefer using handwriting as opposed to using keyboard.

During the evaluation, a mouse was intentionally put on a corner on the table to observe participants' reactions. Interestingly, while in the pilot study some participants used the mouse as opposed to their finger tips to interact with the tool, none of the participants in the formal evaluation used the mouse. Some participants even considered using their finger tips "*much more flexible than using a mouse to click"*.

Implications

By the end of the individual evaluation, we could conclude that both reliability and usability of the system were significantly enhanced by the changes we made. Changing the wording of some tasks after the pilot study might have had an effect on these results; but considering the improvement of some other tasks, whose descriptions were not modified, we believe that improved task performance was a result of the changes in the tool not the changes to the wording of the tasks. Some issues like handwriting and single touch limitation were still seen as hindering. This fact is to be considered when analyzing the results of the group evaluation.

4.2 Group Evaluation (Agile Meetings)

Conducting the individual evaluation was a prerequisite to running a group evaluation. In fact, it can be considered as a control measure over the group evaluation. For one, the group evaluation could not have been conducted with major usability issues in the tool. The other reason is that the individual evaluation revealed some factors that might have an influence on the results of the group evaluation. Thus, upon the completion of the individual study, we could rely on its implications (in the previous section) to start the group study and be confident enough that there is a satisfactory level of objectivity and mitigation of external factors.

Goal

The goal of the group evaluation was to explore the different aspects of using a digital tabletop in agile planning meetings and study its usefulness.

Methodology

This qualitative study mainly depended on observation and retrospective interviews. In this section, we explain how these two methods were employed to help us reach our goal in investigating the practicality of utilizing the digital tabletop tool in agile planning meetings.

Observation. Observation was a rich source of information to us, since we got to monitor an agile team in a series of planning meetings conducted using pen and paper in two occasions and then a digital tabletop using APDT in two other occasions. The observational sessions were held on a biweekly basis. While observing the traditional pen and paper meetings, we were looking at typical collaborative activities and practices the team had to go through during the meeting. This was especially important for the study to make solid comparisons between the traditional setting and the electronic setting (Table 1 was deduced from these observations). When observing the electronic setting, we were interested in observing the practices and activities that participants did more frequently. Moreover, the face to face communication and the opportunity of collaboration amongst attendees were both important aspects to look at. Positive and negative comments were of equal interest to our study. The actual observation was conducted by an observer attending the meeting as a stakeholder but without giving any input. Almost all participants in the meeting did not know beforehand what was actually being observed in the meeting and why. This was mainly to help reduce the effect of evaluation apprehension and self-consciousness they might have had if were told why the meeting was being observed. This was ethically acceptable because there was no video or audio taping, and participants were briefed later and asked to give their input through one-on-one interviews.

Interviews. At the end of the four observational sessions, 10 to 30 minute formal interviews were conducted with the members of the agile team. They were asked open ended questions (like the ones in the box below) to freely express their opinions about using the new technology as a means of collaboration in the planning meeting. Some questions focused on a direct comparison between what they used to do in paper and pen based meetings as opposed to what they did in digital tabletop based meetings. The objective of these questions was not to determine superiority of one method over another, but rather to understand how the two methods differ from each other and in which situations one would be more practical than the other. Another set of questions focused on the use of gestures, handwriting, and voice commands for they were the newest features in the tool.

1. What changes do you think using a digital tabletop posed on your planning meetings?
2. What do you like/dislike most about APDT?
3. If you were given the choice, would you prefer to use the tabletop or pen and paper in the next meetings?
4. Was there any advantage of utilizing a digital tabletop in your planning meetings?
5. Can you think of any situation where the digital tabletop limited collaboration or interaction in your planning meetings?

Participants

A five member agile team working together in one environment was the target of our observation. All members have conducted agile development for several months/years and thus possess hands on experience in agile methods. Since all participants were working in the same laboratory where the tabletop was, they all had a good idea on how to use the tabletop. Thus, there was no need for a training or warm up period. This familiarity with the tabletop did not introduce any bias because the team has never used APDT for planning purposes before this evaluation.

Implementation

In addition to being part of traditional pen and paper meetings, we joined three collocated planning meetings where the tabletop was utilized. Each meeting took on average about 45 minutes. The five attendees plus one or two observers were seated around the table. The

observation process was neither interrupting nor intrusive. As mentioned earlier, since we were observing a team that was originally working in the same laboratory where our tabletop was, our presence as observers was transparent to most of the participants. After the series of meetings we attended, we started to conduct formal interviews with participants to solicit as much information as possible. As per consent of the interviewees, the interviews were audio taped for qualitative analysis.

Because it directly mirrored using a digital tabletop in agile planning meetings, the group evaluation was the most important part of the study. And therefore, we dedicate the following section to discuss and analyze the results of this evaluation.

5. Results

The results of both our observational study and the retrospective interviews are discussed and analyzed in terms of three main aspects: (1) the change of traditional practices, (2) the factors affecting these changes, and (3) the overall preference of the agile team members for using digital tabletop in their planning meetings. We discuss these results while keeping in mind that external effects (such as usability issues) can be mitigated based on the implications of the individual study we conducted earlier.

5.1. Change of Traditional Practices

In the interviews, the participants reported several changes of their natural behaviors while conducting a tabletop based planning meeting. Table 2 summarizes the most common comments into five groups.

Table 2 - Comments related to changes in traditional practices

C1	It is almost the same. The only difference is that traditionally, you can grab the physical card and give it to someone in the hand, but on the tabletop, everything is on the surface.
C2	In paper based [meeting], the story card is too small. You have to pass it around to people one by one so they can see it. On the tabletop it is big enough for everybody to look at it at the same time.
C3	In the pen-paper planning meeting, everybody can write story cards at the same time, but APDT allows only one person to write at a time.
C4	I used keyboard to write on the story card, because the handwriting on the tabletop is hard to recognize.
C5	It is not that I don't like speech [voice control] but it is not quick. I had to say three times "create story card" before it actually did. Finger tip control; however, is much easier.

In the first row of the table, we can see that the participants state that there is a change in the way we interact with things on digital surfaces as opposed to physical objects. This kind of attitude is expected when using a computerized system that imitates real physical objects; however, the comment does not indicate whether the change has a positive or negative effect on the interaction.

The second group of comments (C2) reflects a favorable change. Information sharing was perceived by many participants as one of the most advantageous qualities the tabletop offers.

On the other hand, the third group of comments clearly indicates dissatisfaction with the fact that only one touch is supported at any point of time. From the very beginning, we anticipated this to be an issue. It turned out; however, to have a more serious influence than we anticipated. People actually could notice that this limitation was hindering the interaction that would usually be more dynamic in traditional mode. The DViT hardware is able to provide two concurrent touch points. Going beyond that is not possible with our current table due to hardware limitations.

Using handwriting to fill out a story card is a natural input behavior observed in a traditional pen and paper based planning meeting. In APDT, we developed a feature to support handwriting input on the tabletop. However, a handwriting action was rarely observed in the group evaluation. The participants were observed to prefer using the keyboard over the handwriting feature. The interviews supported our observation because interviewees expressed that it was uncomfortable to write directly on the tabletop surface with their fingers. In addition to the fourth group of comments shown in the previous table, one participant mentioned that *"[his] finger is too thick to write a small stroke clearly"*. This dissatisfaction with the handwriting ability can also be attributed to the fact that using a keyboard is regarded more "natural" in a computer environment. According to our observations, when a user wanted to input something on a card, his/her first action was looking for a keyboard rather than attempting to write on the card. One participant explains: *"I always consider the tabletop a computer with a big, horizontal screen, so looking for a keyboard is always my first choice"*.

Another change to the traditional practice was introduced by the speech recognition feature. Traditionally, in agile planning meetings, collaborators use their

hands to manipulate paper artifacts. In APDT; however, voice commands were introduced as an alternative approach to control artifacts. Our observations revealed that the attendees did not often use voice control although they considered this option *"cool"* and *"amazing"*. The interviews exposed that the main reason behind not accepting this change is that participants perceived the voice control as unreliable as indicated in the fifth group of comments in the previous table. Participants, especially those who were not English native speakers, needed sometimes to repeat their voice commands several times to get a response from the system. Even when they got a response, the system sometimes responded unexpectedly.

The last point to mention in this context is that when observing the meetings, we noticed that the tabletop added a "fun" attribute to the meeting activities. This was more obvious when doing things like throwing a card to a collaborator at the other end of the table, or rotating a card to a collaborator on the opposite side. Over the series of meetings we have attended, we repeatedly heard things like "This is fun" and "That is cool". Although we don't expect this "fun" factor to last for long, we could tell that it can be a basis to encourage fun interaction in the meeting and strengthen bonds amongst team members.

5.2. Factors affecting changes

Section 5.1 described changes of traditional practices while using a digital tabletop to conduct a collocated agile planning meeting. Some of the changes were welcome and even perceived as constructive; whereas others were perceived negatively. In this subsection, we discuss three factors that, based on the participants' responses and behaviors, had the strongest influence on the participants' attitudes towards the introduced changes. The implications of analyzing these factors are expected to guide future design of tabletop based agile planning tools. The three factors are:

1. Responsiveness

Defined as how fast the system responds to the users' commands, responsiveness played an important role in determining the practicality of using the tabletop in agile meetings. Since an agile planning meeting is a dynamic activity during which group collaboration is strongly encouraged, poor responsiveness of the system might hinder or delay the interactive processes. This hindrance was very noticeable in the agile planning meetings we attended, and was explicitly mentioned by some participants as a source of disturbance. Therefore, we can conclude that in order for any planning tool to be used effectively in an agile context, it has to have timely responses.

2. Simplicity and Accuracy

Users' preference is strongly influenced by the simplicity of the interaction and the level of accuracy needed to accomplish this interaction. Users tend to value simple and reasonably sensitive operations over complex or over-sensitive ones. According to Nielsen et al [27], simplicity is an essential component of user experience. This was the case in our study even when the complex alternative was perceived as more "natural". For instance, using handwriting on digital tabletop is a natural extension of using a pen to write on paper story cards. Nevertheless, participants were more likely to use a keyboard because it was simpler and did not demand accuracy. Whereas handwriting was a complex process that involved multiple steps. And due to the unnatural thickness of the electronic marker's tip, the user was required to be accurate when using the electronic marker to write contents.

3. Ownership

By ownership, we refer to the possession of control over an artifact on the digital tabletop. This proved to be another important factor that played an essential role in forming the users' behaviors. When a user creates a story card, he usually possesses the card and, just like what would happen in a traditional meeting, he might choose to edit the card and keep it close to him, or hand it in to another collaborator. Traditionally, this process is very seamless and dynamic because it is ruled by social protocols (e.g. first person to touch the card owns it). However, with a tabletop, it is hard to observe such social protocols playing role in determining ownership. According to our observation, collaborators did not perceive electronic cards as real assets, and thus did not always consider social protocols when attempting to grab a card.

The technical aspect also has a contribution to this issue. The problem of ownership gets more acute because of the hardware inability to support multi-touch interaction. Some participants in our study indicated that the main reason they may not choose to operate on a tabletop in a planning meeting is the ownership problem.

Ownership is an issue that will be investigated in order to reach practical solutions such as "first-touch-wins" or "last-touch-wins" depending on the situation and the specificity of the context. Applying these solutions will be an attempt to impose protocols on electronic ownership similar to the social ones in paper-based interactions.

5.3. Users preferences

Except for one participant in our group study, all participants showed preference towards utilizing a digital tabletop in their planning meetings. Interviewees mentioned different reasons to rationalize their favorable perception such as the ones shown in Table 3. These positive perceptions might be moderately biased due to the excitement and "coolness" that innovative technology usually creates. A longitudinal study over a few month period of time is required to make more solid conclusions on this aspect.

Table 3 - Why the team found APDT beneficial

Subject	Comment
S1	I found it quite similar to manipulating cards on a real table. But using tabletop can save the cards automatically after the end of the meetings. Moreover, some functions, such as rotation and resizing are interesting.
S2	It is very intuitive and it has good visual representation of everything.
S4	I think it is sophisticated with something new. And it works well.
S5	I think it has cool functions and nice features to support most of the operations I will do on the meeting.

Participant who didn't prefer to use the digital tabletop in future meetings reasoned out his preference by saying: *"Now, I prefer paper based meeting. But I will move to tabletop after it supports the multiple finger touches."* This conditional statement clearly reflects the importance of using APDT on a hardware that supports multi-touch to encourage more collaboration and cut down racing situations.

5.4. Critical reflection

Although the design of the evaluation was refined after the pilot study to help deduce valid and reliable results, these results are yet to be generalized on a large scale. First of all, we believe a more longitudinal study is needed to eliminate the "coolness" factor that may have biased the participants' reactions towards the new technology. Also, more teams are to be observed before we can make solid generalizations about the practicality of the tool in agile contexts. The fact that most of our participants are computer science students might also have biased their preference to use technology as opposed to traditional pencil-and-paper. These issues will be taken into consideration in future evaluations of the distributed mode of APDT.

6. Conclusion

A variety of solutions have been proposed to enhance agile planning meetings through the use of electronic devices. While some solutions are unable to provide sufficient coverage of all practices required in the meeting, some others introduce disturbing changes to the original setting of the meeting. Our proposal to employ digital tabletops in agile planning meetings for collocated teams resulted in the development of Agile Planner for Digital Tabletops. APDT is a shared planning tool with which collaborators interact using their finger tips. With a single touch support in the current version, simply lifting one's finger allows somebody else to control the touch point. And now that we have multiple keyboards, even text input is easily shared between team members.

Our approach was evaluated through two different yet interrelated studies. The first study aimed to look at the usability of the tool, and the second study aimed to look at the usefulness of the tool in agile contexts. After improving the tool design, we reached to a promising usability level. Study subjects were quickly able to learn how to interact with APDT and accomplish their tasks. Yet, there still are some usability issues, especially related to handwriting support. The group study which involved a real agile team over a series of planning meetings showed a favorable attitude towards the added benefits of the tool such as persisting planning artifacts and allowing for more flexible manipulation of these artifacts like (re-)coloring and resizing. In general, the changes that the tool introduced to the agile team were neither disturbing nor destructive. The tool maintained the circular setting around a tabletop and encouraged interaction amongst collaborators. On the other hand, some factors like system responsiveness, task complexity and ownership introduced some negative influences on the smoothness and dynamicity of the meeting.

Future enhancements will take these issues into consideration in order to reduce the impact of these factors. The system performance will be improved to ensure that cards are following finger gestures in real time.[2] Support for multiple simultaneous touches is being investigated, but is limited by the hardware incapability of accepting more than two simultaneous touches. More observational studies are to be conducted to solicit more solid conclusions on the practicality of utilizing digital tabletops in agile planning meetings.

[2] When we were running APDT on improved tabletop hardware in another lab, lag times were not noticeable.

We also believe that APDT will really shine in distributed planning settings where using index cards is simply impractical. As a result, we are currently integrating APDT and DAP. Overall, our empirical results indicate that tabletop-based planning tools are a promising approach to support collocated teams in iteration planning and have less impact on team interactions than existing electronic tools.

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