TableTops in the Classroom: Reflections on a Multi-year Project

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Abstract: In this paper, we review our findings from three years of research into multi-touch tables to support collaborative learning in classrooms. Findings indicate that multi-touch tables can lead to the development of joint problem spaces and more interactive discussions, and that when placed in a classroom setting, can be used to facilitate small group, bewteen-group and whole-class learning. However, the use of tabletops in a classroom setting requires consideration of the complex nature of the classroom environment, and attention must be paid to how the teacher, technology, teams and tasks fit together.

Keywords: Multi-touch tables, classroom research, Collaboration, CSCL

1. Introduction

Multi-touch tables allow multiple users to interact with the same content simultaneously, which has the potential to change the way groups of people work or learn together. Decades of research point toward the value of collaboration as a pedagogic strategy, [2, 15], with evidence pointing toward the benefits of group work for problem solving, learning and transfer. However, despite its apparent usefulness, classroom research indicates that even when students are seated in groups in classrooms, they rarely work in groups, and collaborative learning is a rarely used strategy is most classrooms [4]. The concept of placing multi-touch tables into classrooms, creates the opportunity to allow collaborative learning to occur more seamlessly, with easier management of the groups, content and interaction for the teacher, and better collaborative engagement by the students [5, 8].

Research on the use of multi-touch tables for learning is beginning to indicate that they can be useful for supporting small group interactions. Findings indicate that groups who use multi-touch engaged in more task-focused, and less process-focused conversation than groups using single-touch [6], and that the use of a multi-touch table supported the development of a joint problem space and more interactive discussion when compared to paper [9]. Tables have also been used to implement a range of learning activities, from biology and physics to story-telling and music [e.g. 7, 16, 17, 18] , where findings indicate that groups can use this technology to engage in complex collaborative learning activities.

However, the placement of multi-touch tables in classrooms requires an approach that considers how the groups will be supported by the teacher, how small group and whole class activities will be integrated during a series of activities, and how the collaborative activities fit into the broader curriculum of the class. In the studies described below, we have approached the data from a number of different angles to create a broad understanding of the issues involved in using multiple, multi-touch tables in a classroom setting, in order to develop a deeper understanding of the issues involved in placing tabletops in classroom environments.

2. Method

2.1 The SynergyNet Multi-Touch Classroom

The multi-touch classroom contains four sit-to-use multi-touch tables, a multi-touch podium, which is used as the teacher orchestration desk and interactive whiteboards (see Fig 1). The student tables have 3 sides that students can sit at, and between three and six students can sit comfortably at the table. The technology in the room is networked, to allow the teacher to pass content to the student tables and between the student tables and the interactive whiteboard. Content can also be passed between tables for between-group activities. As work in the classroom developed, a tablet device (ipad), and then a gesture recognition system (kinect), were integrated into the device ecology, to facilitate teacher orchestration of the room without being limited to a particular device or location in the room. The classroom is equipped with ceiling-mounted cameras to capture two views of each table, and fishbowl cameras to capture the whole classroom. Each multi-touch table has an embedded directional microphone, to collect audio of the groups, and screen capture software is used to collect the on-screen activities for each table.

Figure 1: The SynergyNet Multi-touch Classroom

2.2 Activities for the Multi-touch Classroom

A number of activities were created for use in the Multi-touch classroom. In this paper, we will focus on two – Mysteries and NumberNet.

2.2.1 Mysteries

One of the primary activities we have used in the multi-touch classroom is based on mysteries, a pedagogic strategies designed by Leat & Higgins [11]. In mystery tasks, students are asked a question, and given a number of clues that they need to put together in such a way as to answer the question. The mysteries are designed to contain more information than is possible for one student to make sense of alone, and therefore require collaborative interaction in order to solve the task. We have used divergent history mysteries where there is no single correct answer, which encourages the students to explore a range of possible answers, and convergent mathematics mysteries, where there is a single correct answer. In both types of mysteries, some of the clues contain necessary information, while others are less important or irrelevant to the question.

2.2.2 NumberNet

A second activity that was created for the multi-touch classroom was developed from the traditional "make up some questions" mathematics task that is commonly used in classrooms. In the classroom task, individual students are given a target number and asked to come up with as many expressions (or questions) that create that target number. The task can be approached using either a pattern that uses the same operator (e.g. 100+0, 99+1, 98+2 etc) or using a wide range of expressions (e.g. 100*1; 50+25+25; 200/2 etc). The way a student approaches the task gives the teacher a snap-shot of how flexible and fluid students are with particular mathematical approaches, but does not lend itself to interaction or learning for the students.

An adaptation of this task, NumberNet, was built for the multi-touch classroom to create opportunities for within and between-group learning [7] . In this new application, each table of students receive a target number, and have to create as many unique mathematical expressions to make that target number within a certain length of time. This gives students the opportunity to negotiate and help their group members create new expressions. The target number and correct expressions are then moved to the next table, where the students continue making unique expressions, having the opportunity to learn from the expressions made by earlier groups.

Orchestration tools for NumberNet were placed on a tablet device (iPad) to allow the teacher to move around the room, while still having access to the tools. These tools included live updates of the expressions that each student was creating, which were flagged red if they did not match the target number, allowing the teacher to quickly see if one particular student or group of students were struggling with the task and intervene as appropriate. This data was also available to the teacher after the activity was complete, to review the types of expressions each student created, which could be used as a type of formative assessment, giving the teacher information about support students might need in future classes.

2.3 Study Design and Data Collection

The data that is reported in this paper is drawn from three studies conducted between 2009 and 2011. In all studies, the participants were drawn from local state primary schools. Members of the research team visited the schools to describe the study and, in the case of NumberNet, conduct pre-test data collection. Students were then brought to the Multi-touch classroom in groups of up to sixteen. Informed consent was acquired from the parents or guardians of all participating students. All students who used the tables spent about thirty minutes using applications that were created to help them learn to use and become familiar with the tables before data collection began.

2.3.1 Study 1: Single Table

The first study compared students working on a single multi-touch table with students working on a paper-based version of the same activity. Participants were 32, year six pupils (10-11 year olds) with 16 boys and 16 girls in the sample. Eight participants came to the lab together, working first on a history mystery and then on three maths mysteries in groups of four. One group completed the history mystery on the multi-touch table, while the other used paper, they then swapped locations, and competed the maths tasks on paper, while the other group used the multi-touch table for the maths mysteries. Video was collected for groups in both conditions, which were transcribed for analysis.

2.3.2 Study 2: Classroom Study

During the second study, ninety-six year-six students from six schools came into the multi-touch classroom, in six groups of sixteen. The students spent up to five hours in the lab classroom, working on the maths and history mystery tasks, as well as piloting new activities. The video, audio and screen capture were synced and transcribed for analysis.

2.3.3 Study 3: NumberNet Study

During the third study, forty-four, year-five students from two schools came to the multi-touch classroom, in three groups of between fourteen and sixteen. They spent half a day in the lab, working on NumberNet, and other multi-touch activities. The video, audio and screen capture were synced and transcribed for analysis.

3. Results

3.1 Tabletops to support collaborative groups

In our initial work with a single-table we reported that groups who used the multi-touch table to solve a mystery task engaged in more interactive comments (elaborating and negotiating), than students in a similar paper-based task. In both the paper-based and multi-touch condition, students took turns reading clues aloud at the beginning of the task, however, the way the group interacted once the clues had been read differed between the conditions. In the multi-touch condition, clues were enlarged, and all students looked on, while one student read aloud. In most groups, they then discussed the relevance of the clue before organizing them on the screen in areas that denoted relative importance or the need to return to the clue when more information was available. In the paper-based condition, students often shared out the clues, picking them up and reading them aloud, but with little discussion afterwards, so that all the clues were read before the group engaged in discussion of the clues or their relative importance. Thus, in the multi-touch condition, groups were able to develop a joint understanding of the task, or a joint problem space, more quickly than in the paper-based condition [9].

In the second study, the classroom study, groups of students worked on a logic mystery, which could be solved by placing the clues in a circular pattern (See Fig 2). Of the 24 groups in the study, 13 solved or almost solved the task. Of these, 12 groups arranged the clues on the table in such a way as to track their progress on the task, creating an external representation of the solution process. In contrast, only two of the eleven groups who did not solve the task, used the table to display their progress.

Taken together, these findings indicate that the multi-touch table has the potential to be used in ways that support collaborative problem solving, although the design of the task, and the students' understanding of how to use the resources available to them to support their interactions are key to taking full advantage of the hardware.

Figure 2: Screen shot of circular pattern to solve Dinner Disaster Mystery (start with clue at the top and move anti-clockwise)

3.2 Within and Between-Group Learning with Tabletops

Networking the tables, interactive whiteboard and teacher tools allows us to explore the role of between group interaction in the multi-touch classroom. During the mysteries task in the second study (classroom study), the teachers projected the content from the students' tables to the interactive whiteboard at various points during the activity to facilitate a whole-class discussion about the task. In each of the six classes in study 2, the history mystery, lasted about half an hour, usually with two whole group discussions during the task, and one final discussion to summarize the groups' decisions, leaving three separate small group discussion during the 30 minute segment. Transcripts were coded for the complexity of reasoning within the group (SOLO), and highest level of reasoning in each group or whole-class discussion identified. The SOLO (Structure of the Observed Learning Outcome) taxonomy is a hierarchical taxonomy that classifies the level of complexity in reasoning [3]. The levels range from pre-structural, where no complex reasoning is evident, to extended abstract, a level in which multiple ideas are drawn together to create an explanation. The adaptations to this scheme are described in detail elsewhere [9], and were used to identify students who read the clues, but did not make any comment (pre-structural), comments that included a brief statement about the value of one clue (unistructural), comments where the value of a clue was described in relation to another clue or prior knowledge (multi-structural), comments that drew on the clues to put together an explanation for the mystery (relational) and comments that drew on clues and prior knowledge to develop an explanation (extended abstract).

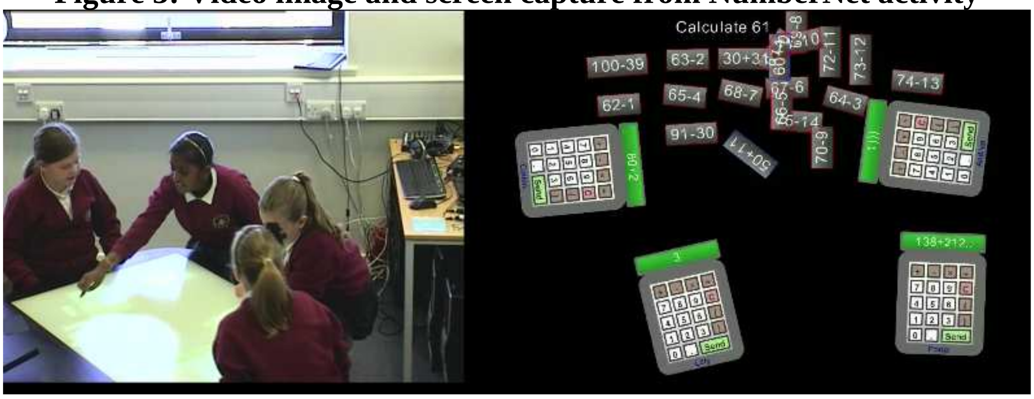
Results indicated that while there was little change in group reasoning after the first whole-class discussion, about half the groups increased in their level of reasoning after the second whole-class discussion. There does not appear to be one simple cause for this, and groups were not simply copying the highest level of reasoning used in the whole-class discussion, instead there appear to be a number of explanations. One cause may be the teacher signaling to the students that the task was almost over, so prompting them to engage in higher levels of reasoning in an effort to come up with a final answer. A second reason appears to occur in groups who discussed their current ideas during the second whole-class discussion. Regardless of the level of reasoning used in the whole-class discussion, these groups tended to return to their ideas, and develop them further, perhaps responding to the knowledge that they now had an audience for their ideas and needed to elaborate them fully in order to discuss them in the final whole-class time [13].

A second example of between group interactions in the multi-touch classroom comes from data collected during a study of NumberNet, the tool developed to explore between-group learning on a mathematics task. During this task, each table of students created unique expressions to make a target number, and then the teacher rotated the correct expressions and target number to the next table. Each table had to continue creating unique expressions for target number, therefore, the task got progressively more difficult as the obvious expressions were created by the first or second group to get the number. However, groups also had the opportunity to look at the expressions created by the other groups before they started making new expressions. This provided an opportunity for the groups to consider different approaches to the task, and try to implement new strategies. In one instance, we see a group identifying that another group had used multiple operators in their expressions, which increases the range of possible expressions available. Throughout the rest of the task, this group experiment with expressions with multiple operators, helping each other to create more complex expressions than they had up to that stage.

Another example of using the work from another group to stimulate creative expressions was identified when one group received a target number where a lot of expressions had already been created. Rather than struggling to come up with new expressions, Poppy suggested that using the commutative property of addition could help them come up with many more expressions, sharing this idea with the group and helping them understand this feature of the addition process (see Fig 3)

Poppy: *I've got an idea, do the opposite way, like 3 times, add...*
Amy: *And they've already done that Poppy.*
Poppy: *Yeah but the other way round*
Amy: *What? Like 60 add 1?... 60... 30?*
Poppy: *Imagine that but just turn it round*

Figure 3: Video image and screen capture from NumberNet activity



4. Discussion

The research presented in this paper points toward the complex nature of using multi-touch tables in a classroom setting. While this technology has potential to support collaborative learning, their value must be understood in relation to the complex nature of classroom interactions. The first two studies reported indicate that the tables have the potential to support collaborative interactions, particularly if the students are prepared to leverage the resources that are designed into the tables.

The second two studies indicate that placing multi-touch tables in a classroom setting has the potential to facilitate whole-class and between-group learning as part of the collaborative learning process. However, the complexity of the classroom and collaborative learning context requires detailed analysis in order to fully understand how best to support learning. For example, in study 2, the first classroom study, the teachers used the orchestration desk (see Fig 1) at the front of the room to send content to the tables and project student content from the tables. The teachers could also monitor the student tables from this desk. However, teachers did not use the orchestration desk to monitor the tasks, rather they moved around the classroom, observing the groups directly and intervening when needed. While this direct interaction was more natural for the teachers, they were removed from the orchestration tools, which hindered their ability to capture and project interesting content immediately. Thus, in the NumberNet study (study 3), and in later versions of the classroom, orchestration tools were place on a tablet device for the teacher to carry with them. This solved some of the problems, although created an issue when the teacher wanted to interact with a student table and had to find somewhere to place the tablet. We are currently exploring the use of gesture recognition in the classroom as an alternative mode of classroom orchestration, which will allow the teacher to manage the classroom without being tied to a single location or device [14].

While most groups engaged appropriately with the tasks, as we report elsewhere, the students were not always able to manage their collaborative process, or understand the tasks without teacher support. This indicates a need to provide teachers with information on how each group is progressing with tasks (as was done in the NumberNet activity), and providing instruction and practice in collaborative behavior for the students who use this type of classroom environment.

Tabletops have huge potential to support collaborative learning, but they must be considered in light of the classroom environment. The possibility of placing multiple, multi-touch tables in classrooms requires that we consider how they can be part of the device ecology within the classroom, which can then be used to facilitate orchestration of the devices and collection and use of data on the students' learning, and the creating of new types of classroom learning and interaction [19]. While these opportunities for the design of new types of learning move forwards, it is essential must be done in a backdrop of theory that places the technology, the desired learning, the learner and the context into frame [10, 12] understanding not just the individual designs of learning experiences, but how they fit together in a complex learning environment [1].

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