Collaborative 1:1 With Emerging Markets Available ICTs

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Abstract: Wirelessly interconnected handheld devices allow Collaborative 1:1, or face-to-face Computer Supported Collaborative Learning, which has shown to be a technology that fosters collaboration and constructivist learning. Dissemination of the technology has been slow mainly due to the technology cost. To provide Pocket PCs to a whole classroom is beyond emerging markets reach. Mobile phones are an alternative. Users buy them, releasing public money to be invested in the classroom technology. A second alternative is Single Display Groupware, where different users share the same display each withy their own pointing device. In this paper, we show how these widely available technologies can be used for achieving these same objectives as Pocket PCs have previously done.

Keywords*:* Collaborative 1:1, Face-to-face Computer Supported Collaborative Learning, Multiple Mouse, Single Display Groupware, Mobile Phones.

1. Introduction

Technology has gone different steps in education. A first step was learning with technology, where software was used to perform activities and retrieve information necessary to produce and reflect on a given assignment. Later on, higher order thinking skills could be supported by helping students to express and articulate what they know by doing and creating their own representation of the problem. In this way computer programs helped not only as productivity tools to achieve the school curricula but also as cognitive devices that assisted to reflect, explore, construct and visualize (Juniu 2006).

Social learning systems, cooperative systems, or collaborative systems adopt a constructive approach using the computer more as a partner than as a tutor. These systems also use the computer not as a directive training means but as a way to exchange, control and build knowledge within peers (Ai'meur et al 2001). Computer Supported Collaborative Learning (CSCL) (Crook 1994) focus is not so much on the individual who learns and thinks, as it is on the collaborative group that explores and reasons. Its focus is beyond technology and requires understanding cognition, communication and culture and its social settings.

When computer supported collaboration occurs in a same place with children working face to face in a small group, we talk of face to face CSCL, or Collaborative 1:1, possible with wirelessly interconnected PDAs, as Pocket PCs, (Zurita & Nussbaum 2007). In this case, we can recognize two networks. The social network, where group mates interact verbally, and the technological network that transparently supports the social network activities, by coordinating and synchronizing activity states, and mediating the activities and the social interaction of the peers (Zurita & Nussbaum 2004a)

Even quantitative and qualitative results have been shown for Collaborative 1:1, its dissemination has been slow due to the technology cost, since to provide equipment to a whole classroom the cost is beyond an emerging market economy budget. However, there are other platforms which are available in these countries, PCs and mobile phones. In this paper, we show how face to face CSCL can be implemented in these platforms and its implications.

2. Single Display Groupware (SDG)

In developing countries, a common problem is the high student-to-computer ratio. One solution is to sit more than one child behind a screen. Since today's computers are designed with the assumption that one person interacts with the display at a time, one child controls the mouse, while the others are passive onlookers, without operational control of the computer.

Single Display Groupware (SDG) lets multiple co-located people, each with their own input device, interact simultaneously over a single communal display. While SDG is beneficial, there is risk of interference; when two people are interacting in close proximity, one person can raise an interface component (as a menu, dialog box, etc.) over another person's working area, thus obscuring and hindering the other's actions (Tse et al 2004). The solution is to provide each child with a mouse and cursor that controls their own objects on the screen, thus effectively multiplying the amount of interaction per student per PC for the cost of a few extra mice (Pal et al 2006, Pawar et al 2007). A key issue therefore, is to create appropriate sharing mechanisms of the critical resources (Stewart et al 1999).

By explicitly providing for separate input channels, the workspace in front of the PC may be decreased enough to allow three children to interact with the same computer simultaneously (Pal et al 2006). Different collaborative interactions that make use of multiple simultaneous users at a single computer can be contemplated. The question is when are more hands on a screen better than one, and how complex can SDG applications become without introducing frustration among team members (Stewart et al 1998), An example where this is highlighted is in (Stanton el al 2003). They show a qualitative analysis where children using two mice divided up their task, worked in parallel, but showed limited reciprocity and elaboration of ideas, while children sharing one mouse demonstrated varied behaviors ranging from highly collaboratively work to extreme domination by one partner.

2.1. Exchange: An application of SDG.

Exchange is an application developed originally for PocketPC (Zurita & Nussbaum 2004) that was adapted for PC using Multiple Mouse (MM) for three users. Each participant has a question and an answer, but not necessarily the answer of each one corresponds to its question. The objective of this application is that participants interchange answers until each group member has the correct pair (question/answer), Figure 1.

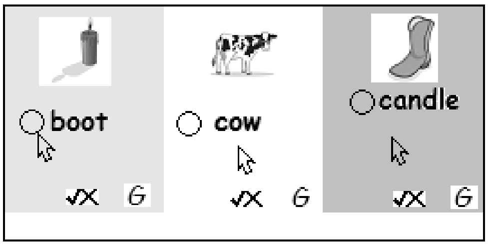


Figure 1.1. Each participant has a question and an answer, but some pairs (question/answer) are incorrect.

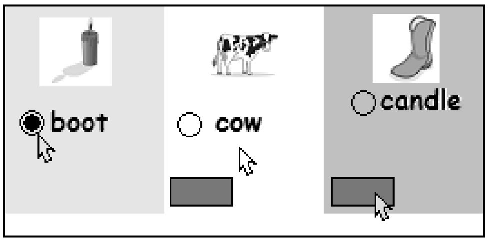


Figure 1.2. The student on the left decides to hand his answer, selecting it. One of the two other two participants can accept it, by selecting the corresponding button, or both reject it.

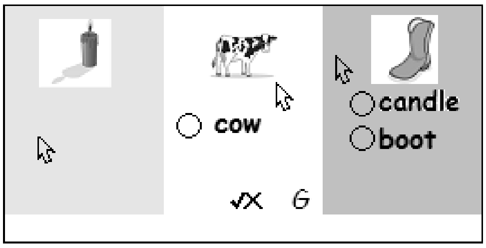


Figure 1.3. The student on the right takes the answer given by the student on the left. The student on the right has now two answers and has to decide which one to cede to the other group members.

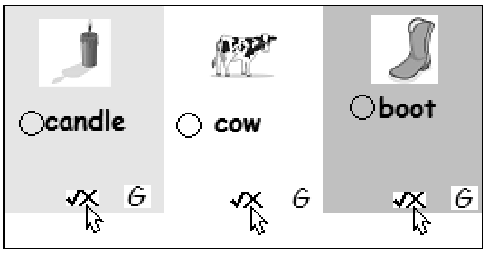


Figure 1.4. Finally, through interchanges all have their question/answer as they think is correct. They verify their answers with the system. If all of these are correct they proceed to the next question, otherwise they try again.

Figure 1: Definition of the Exchange Activity

Participants have a mouse which controls a cursor. Each cursor is identified by a specific color. Even a cursor can go to any place of the screen, the instructions participants perform are only accepted by the screen area that has the same color as the corresponding mouse. This allows sharing a common space while simultaneously permitting each child’s individual contribution to the collaborative activity (Tse et al 2004), illustrated in Figure 2.

Figure 2: Three children sharing a screen in the MM Exchange application.

The application allows a balanced involvement of the three group members. The implicit coordination mechanism forces each participant to do a task, which has to be one at a time. In order to successfully complete the activity, a child must not only achieve his own individual goal, but also help that all children in the group reach their goals. Besides, the social interaction between participants is promoted. To exchange objects, participants have to communicate ideas, interchange opinions and concepts, and negotiate among them. Consequently, pedagogical and social support networks are generated between the participants.

2.2. Implementation of the Exchange Multiple Mouse application

Exchange is an application that existed on Pocket PCs (Zurita & Nussbaum 2004b) and migrated to SDG using the library for Multiple Mouse described in (Pal et al 2006). This library, devolved in .NET, maintains separated the signals of the different mouse connected to a computer, which allows discriminating the execution of the different mice. Therefore, the movement of each mouse is shown in the screen by its own a cursor.

The original architecture of Exchange for Pocket PC is based on a master/slave scheme (Zurita & Nussbaum 2004b). The teacher has a device that acts as master, while the students work in groups of students as slaved devices. In the master/slave architecture only the master (teacher) makes updates, i.e., the logic of the application is in the master while the slaves inform the actions that are made. The activity state, represented by a vector, is periodically sent by the master to the peers who then update their corresponding screen.

The logic of the application remained when porting to SDG. The work consisted in adapting the program interface to MM, unfolding in one screen what is originally shown on three Pocket PCs. The original master/slave architecture remained eliminating only the network management, considering that the three users were now on the same machine.

2.3. Experience of SDG with Exchange

The usability of the Exchange program using MM was tested through a two month experience with a frequency of once a week with 38 students of second grade (eight years old) of a low income school. Students were randomly divided in groups of three every session, each having a mouse.

The children already knew the use of a mouse and where familiar to the PC. The Exchange program, was easily mastered, some of them in the first session. Familiarity with the hardware and simplicity of the software allowed that the technological network were not an obstacle for learning, but a suitable support to verbal interchange and mutual aid. Thus, the student efforts were dedicated solving learning problems posed in the software activity. There was a low necessity of student external support.

The activity logic, where the control of the action is shared, plus the fact of each child having a mouse facilitated the group experience. Changing randomly group members allowed that those who better mastered the contents taught others in a natural way, plus social equilibrium.

The bigger screen, compared to that of Pocket PCs, allowed better graphics, and more information. There were doubts if the single screen could affect the reflection and collaboration process. It clearly did not happen. Students fixed its attention on the common screen, Figure 2, where individual resources were shared, and reflection and collaboration occurred. The screen, from an instrument of visualization become a learning place where students discussed. They talked about objects on the screen and actions to perform. They used their fingers to point on the screen to explain their peers, Figure 2. Discussion and mutual learning, without preventing individual work, was clearly observed

Throughout the experience we observed that the students had a high level of concentration doing their tasks, while maintaining motivation and a remarkable group joy when successfully finishing an exercise and pass to the following one. The same was observed when finishing the whole activity, which strengthened the group bonds and the common feeling to belong to a work team doing a shared task.

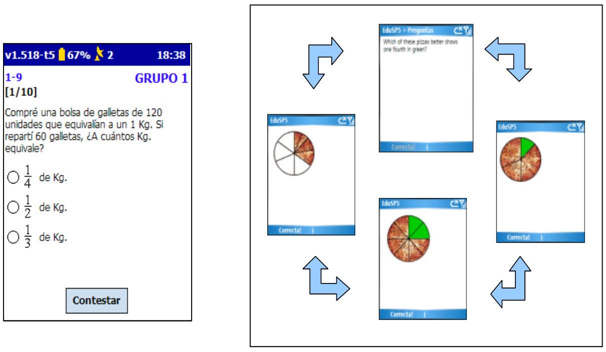
3. Phones

The rapid proliferation of mobile phones among students is generating a novel platform for the development of classroom interaction systems. These, used in task-based learning, have the potential for a distributed practice encouraging classroom interactivity (Meurant 2006). Phone learning relies on email and SMS as the main methods of communication between learners and learners, and learners and instructors. Social presence through synchronous instant messaging provides learners with continuous awareness of available support and encourages sharing of learning experiences (Kekwaletswe and Ngambi 2006). With some software's the teacher can project messages and develop an interactive loop with students during the class (Markett et al 2006), even extending the communication with visual media reducing the students cognitive load (Lindquist et al 2007). This sort of communication is however inadequate for learning situations where oral communication between students is encouraged (Schwabe and Goth 2005) as in face to face CSCL.

Mobile phones inherent learning limitations can be synthesized as follows (Shudong and Higgins 2005):
1) *Narrow Output*. Small screens and low resolutionhas to be considered in the amount and type of information that can be delivered to user.
2) *Restricted input* delivers a slow and inconvenient delivery of information from the user to the device. Specially designed keyboards have shown fast input but require a lot of training.
3) *Limited network capabilities*. Most learning applications are SMS based, therefore using the phone company as the network hub, making communication between devices restricted because of the different commercial models behind.

3.1. MCQ: a face to face CSCL application on a wireless network of phones.

In (Cortez et al 2005) we describe an application where participants arranged in groups of three, have to answer a set of multiple choice questions (MCQ) collaboratively in their wirelessly interconnected Pocket PCs. The logic of the collaborative activity is that all the members of a group are forced to discuss to reach an agreement before answering the question. If the students do not accord in the answer, the system will ask the same question again until everyone in the group agrees on the same answer. Only then, the system validates the answer. If the answer is incorrect, the system informs the group and makes them answer the same question, omitting the selected alternative, until the answer is correct. Finally, if all the members of the group select the correct answer, the group can reach the next question of the test. Figure 3a illustrates a screen shot of a group members' machine, where we can see a question with its corresponding alternatives.



(a) Pocket PC (b) Phone

Figure 3: MCQ activity screens;

Considering this application, we wanted to study how the same application could be implemented on a network of wirelessly interconnected phones, we used Imates' SP5 phone with WiFi, a low resolution screen and no stylus.

From the users' side, the biggest difference was the way in which questions and alternatives were displayed, Figure 3b. Considering the small screen size, it is not possible to show the same amount of data as in the screen of a Pocket PC. A set of consecutive screens was chosen, selected via buttons of the telephones' keypad. From the input side, there was no difference since the student just selects and alternative, activity performed through one of the available keys.

3.2. Implementation of MCQ on phones.

A similar system architecture as on the wireless network of Pocket PCs was implemented on the wireless network of Phones. The main consideration was that there was less computing power on the Phones available, comparing it with the one of the Pocket PCs. The consequences of this were:

1) To reduce the load of the network and allow sending the files of each of the screens, a file compressor had to be developed to compress files on the Server (teacher) and to decompress them on the slaves (students). The cost of this was that the server could not be another phone but a bigger machine, as a Pocket PC, while the students had to initially wait more time on phones, than on Pocket PCs, for receiving the activity due to the decompression time.

2) On the pocket PCs, each time a TCP connection was established with another device, which occurred when messages are sent or received, a new thread was created that received the message, processed it and handed it over to the upper layers. This optimized network and CPU usage when simultaneous messages were received. Considering that the processing power of the phone is less than on the Pocket PC, the number of possible simultaneous threads is much smaller on the phone than on the Pocket PC. Therefore, on the phone messages were queued waiting to be sequentially processed.

3) On the phones, the WiFi network was less reliable than on the Pocket PCs. The number of attempts was therefore increased. While on the Pocket PCs an error message was informed after three attempts, on the phones this was increased to five.

4. Conclusion

Many technological innovations to improve learning, beside the necessary pedagogical content creation, entail huge hardware investments and require spending a lot of money in infrastructure and facilities not affordable by schools and governments in emerging market countries. Phones and the use of existing computing infrastructure is therefore an attractive alternative. SDG requires only purchasing two additional mouse for each current PC which allows to optimize the use of the computational infrastructure by placing three students behind a same screen. For collaborative 1:1, SDG has the additional convenience of not requiring a wireless network, improving reliability, and is not subject to the portable technologies load batteries restriction.

Children frequently fail in learning situations because they cannot store and manipulate information in working memory. Children may simply forget what they have to do next, leading to failure to complete many learning activities. Also, in activities that involve storage and processing of information, working memory demands can be a problem (Packiam 2006). In the phone implementation memory demands are increased and in our initial tests we have seen that small children have problems dealing with the sequential question presentation model of Figure 3b. We have to do further studies with different group age.

Simply assigning students to groups and telling them to work together will not necessarily promote collaboration or group achievement (Nussbaum et al 2007). The tasks chosen for peer collaboration need to be appropriate to the capabilities of the individual learners, the technological capabilities of the underlying infrastructure, and structured so that children work together cooperatively for successful completion. (Zurita & Nussbaum 2004b) identify a set of key factors to achieve an effective collaborative learning environment, analyzed in Table 1 for phones with the MCQ application and SDG with the Exchange application. From there we can see the strength and weakness of each. The seamless feature of Phones is its strength which favors Social face-to-face interactions. Its main weakness is its screen size that impedes to implement applications that favor Mutual Support, as for instance Exchange. On the SDG side, we observe that all the key factors are achieved, but Social face-to-face interactions.

Table 1: Comparison of phones with MCQ and SDG with Exchange.

Key factor	**Description**	**Phone with MCQ**	**SDG with Exchange**
Individual responsibility	Each member is responsible for his own work, role and effort to learn	Each student performs his/her work on its own phone.	Each student owns his/her own working space, accessed through his/her personal pointing device.
Mutual support	Each member must help in the teaching of the others members of the group	Exchange is a better activity for mutual support, but more difficult to implement than MCQ due to the phone reduced screen size.	A child must not only achieve its own individual goal, but also help to ensure that all children in the group reach their goals.
Formation of small groups	Commmunication, discussion and consensus occurs in small groups physically close	The small size of phones allows the closeness of participants and so the formation of small groups.	As Figure 2 illustrates, the proximity that sharing a screen requires makes them to be close to each other.
Device and system appropriation	Students quickly master the device and system so that they effort is placed only in the academic task.	The use of mobile phones is straightforward. But, braking MCQ exercises in different screens, is difficult to understand for small children.	Students quickly learned to use MM and Exchange because they are used to the use of the mouse and the simplicity of the application.

We have shown how commonly available technology can be used to foster face to face computer supported collaborative learning. Future work has to be directed in different directions. More research has to be invested in applications with small screens, that reduce memory demands without increasing the input demands. Additionally, different activities have to be sought for phones that consider the key factors for an effective collaborative learning environment (Zurita & Nussbaum 2004b). From our initial experience, we have seen that SDG is an excellent tool for small children, since all the collaborative information is available at once on the same screen. We have to observe how grown up students behave under the closeness of working three persons behind the same screen.

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