# Supporting rich interaction in the classroom with mobile devices

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## Abstract

*Mobile computing devices facilitate mobility and face-to-face interaction when compared with desktop computing, but lacks of the computing power of the latter. Therefore, a key aspect to ensure success of a learning supporting mobile application is whether mobility is really needed for the activity it supports and if mobile devices do really represent an added value compared with the same application implemented on non-mobile devices. In this work we first analyze the best known collaborative learning practices trying to find out which are the real need for mobility and face-to-face interaction and then design and develop an application called MC-Supporter implementing a, problem-based, collaborative learning application based on these requirements.*

**Keywords:** Mobile CSCL, Social Interaction, Problem-based learning

## 1. Introduction

According to [1], social interaction plays a crucial role in the process of learning, but a large number of students, the seating arrangement, limited time, lack of effective assessment and low students' motivation often hider it. Studies have suggested that Computer Supported Collaborative Learning (CSCL) facilitates learners' communication, enabling high levels of social interaction in the classrooms, [2], [3]. In this paper, we present a prototype of a system called Mobile Collaborative Interaction Supporter (MCI-Supporter) based on PDAs and Tablet-PCs wirelessly interconnected, implementing artifacts and techniques that can improve teacher-student social interaction. The system supports various pedagogical practices requiring rich teacher-students interaction. MCI-Supporter helps teacher to create and distribute any kind of problems to the students and provides tools to asses their work when solving them, thus providing immediate feedback and promoting reflection. All this is made in real time and at a same place supporting the face-to-face teaching/learning situation, [4], [5]. Preliminary tests have shown that mobility helpes to improve the interaction among them and raise their motivation.

## 2. Interactional epistemologies of CSCL

Suhters, [6] holds that CSCL should focus on the design of technologies that facilitate and foster teacher-students and student-student interactions, as this is a requirement for interactional and especially intersubjective learning epistemologies. An intersubjective learning epistemology goes beyond an information sharing conception of collaborative learning in two ways: 1) it can be about sharing interpretations as well, and 2) these interpretations can be jointly built through social interaction among participants, in addition to those created by individuals. Intersubjectivity is to be understood in a participatory sense, and may involve disagreement. In this epistemology, learning is not only accomplished through the interactions of the participants, but learning also consists of those interactions themselves [7].

Developmental learning through social interaction can be understood as the internalization of interpersonal processes as intrapersonal processes, [1]. Therefore, the new practices in CSCL must be reflected in concomitant creation of novel technological artifacts that support and help to replicate these practices of internalization.

### 2.1. Social interaction factor in CSCL

To achieve high levels of social interaction individual active participation as well as dynamic construction of meanings by higher order cognitive process is required. This may involve logical thinking, conceptualizing, analyzing, reasoning, and evaluating

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[8]. Based on this point of view, construction of meanings and knowledge during social interactions does not only involve making students express their ideas or respond to others, but it also possesses "dialogical" features. According to [8] some critical factors of promoting social interaction in the classroom context are: 1) Motivating students' participation: the teacher can trigger the learner's disequilibrium through posing just-in-time appropriate and meaningful **open problems.** This will motivate them to inquire, and enhance the need of **collaboration** by **assessment** and **feedback**. 2) Focusing students' attention: to ensure that students retain their focus has become an important task in classroom interaction. For this, the teacher can provide **coaching** to the student. 3) Externalizing internal thinking: thinking does not 'expresses' itself but must be shared by creating and exchanging artifacts reflecting ideas, for example during **reflection**, and **challenge-based learning** [9]. 4) Constructing mutual and **collaborative** understanding: the interlocutors' intention changes constantly before, during, and after the process of interaction. This affects how he/she expresses thinking and responds to the others (**peer-review**).

Collaborative knowledge building in a classroom often requires students' mobility in order to establish face-to-face interactions**. Mobile CSCL** (**MCSCL**) applications enable three types of interactions among members in the classroom [10], including: (1) one-to-one interaction between two students either in the same or in different groups; and between a student and the teacher (2) one-to-many communication between the instructor and students; and (3) many-to-many communication among students. Nevertheless, mobile CSCL design cannot effectively improve students' social interaction (and learning) without the support of appropriate pedagogical practices embedded on the design of the application.

## 2.2. Social interaction model

We will use the interaction model (see figure 1) proposed by [10] for MCSCL applications, in order to explain the social interactions and pedagogical actions MCI-Supporter is able to support. The components of the interaction model are actors and mediators. The **actors** are individual persons (a single student), a small group, or the whole class. Actors send and receive information through **mediators** which may be a PDA, a Tablet-PC or face-to-face communication. The teacher is both an actor and a mediator, who selects the pedagogical practices to implement and guides the students toward achieving the learning goals. Teacher may provide learning material in form of problems, feedback, assessment, coaching, and reflection to the students, as well as regulate the information flow between them and among the groups, so that the social interactions take the desired course. Information flows among collaborators (actors) mediated by mobile devices (mediators) interconnected through a wireless network.

The interaction model is a template for identifying the MCI-Supporter effects in terms of interaction requirements relating to the actors, actions, communication channels, and communication direction (initiator-responder). Activity specification includes identifying actors and mediators involved, setting out the activity's context and goals, and describing it in terms of the corresponding subset of valid interactions (the paths in Figure 1). During specification, the teacher determines which actions will be mediated technologically (using PDAs) or face-to-face.

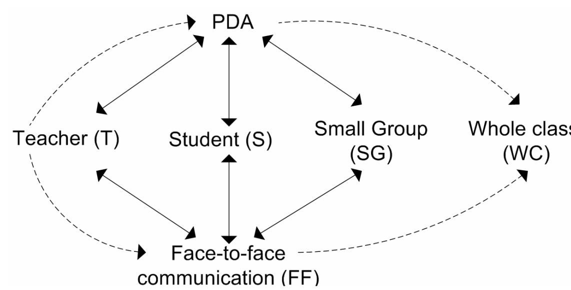



*Figure 1: Straight lines represent teacher-student or teacher-small groups interaction; dotted lines represent teacher-whole class interaction*

## 3. Supported Pedagogical Practices

The pedagogical practices we want to support with the use of MCI-Supporter are:

**Problem based learning:** The characteristics of this learning practice are: 1) learning is driven by open-ended problems; 2) students work individually or in small collaborative groups; 3) teachers take on the role of "facilitators". Accordingly, students are encouraged to take responsibility for themselves and the group, organizing and directing the learning process with support from a teacher. It can be used to enhance content knowledge and foster the development of communication, social interaction, problem-solving, and collaborative as well self-directed learning skills.

**Assessment:** It is a participatory, iterative process that: 1) provides information required by the teacher in order to improve teaching and learning; 2) produces evidence about the learning outcome of the students; 3) evaluates whether changes made improve/impact student learning, and documents the learning and teacher's efforts, [11].

**Coaching:** It is a learning technique that involves observing individual or collaborative work and providing advice to enhance performance or correct deficiencies from "behind the scene". It used: 1) to develop or provide new skills through on-the-student training; 2) to set learning objectives and expectations together with the individual or among the group participants; 3) to mutually develop and agree on a course of action for enhancing performance; 4) to facilitate learning and enhance performance through using observation, listening, and guidance skills. Give constructive advice and encourage and reward accomplishments, [11].

**Reflection:** It allows students to take a metacognitive stance to their involvement in the project to explore their own individual and collaborative learning and to determine how the experience has increased their abilities for future academic and professional experiences, as well as informed them as to what skills they need to strengthen. Effective learning situations require time for thinking. Students also reflect on themselves as learners when they evaluate the thinking processes they used to determine which strategies worked best. They can then apply that information about how they learn as they approach learning in the future, [11].

**Feedback:** It is used to inform learners about the quality and/or accuracy of their responses. Feedback is distinguishable according to its content, which is identifiable by: 1) load, i.e. the amount of information given from yes-no statements to fuller explanations; 2) form, i.e., the structural similarity between information in the feedback compared to that in the instructional presentation; and 3) type of information, i.e., whether the feedback restated information from the original task, referred to information given elsewhere in the instruction, or provided new information. Researchers recommended immediate feedback for conventional educational settings. Some types or levels of feedback include: 1) a mark or grade or success/fail classification of outcome; 2) the right answer; 3) procedural or surface explanation of the right answer; 4) explanation of what makes the right answer correct: of why it is the right answer; and 5) explanation of what's wrong about the learner's answer, [11].

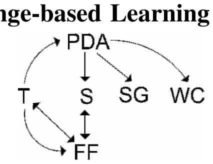
**Challenge-based Learning:** In CBL the question or the problem is replaced by a challenge. This challenge is initiated either by the COLDEX project, a teacher or a student group. The assignments or "challenges" to be solved might include ways to develop, design and implement solutions for problems related to scientific phenomena. A meaningful learning activity consistent with CBL is to present learners with a challenge scenario and to ask them to think about a number of possible solutions using a variety of interactive tools. Such an activity serves to centre thinking around meaningful problems and is typically effective in facilitating small group collaboration, [11].

**Mobile Collaborative Learning (MCSCL):** Mobile technology opens up potentials for students to work collaboratively while they are in movement, rather than working with allocated partners at a fixed desktop. Students can move inside the classroom and interact with other students in any way that they need. In a MCSCL application it is possible to recognize the technological and the social network: they can communicate face-to-face or by means of the interconnected mobile computing devices.

**Peer-Assisted Leaning:** Peer-Assisted Learning (PAL) involves students consciously assisting others to learn, and in so doing, learning more effectively themselves. PAL encompasses peer tutoring, peer modeling, peer education, peer counseling, peer monitoring, and peer assessment, which are differentiated from other more general "cooperative learning" methods, [11].

Table 1 describes the activities the system supports and which are the Learning Practices implemented through this activity.

*Table 1. Learning activities supported by MCI-Supporter, the Pedagogical practices they support and the interactions that take part*

<table>
<tr><th>Pedagogical Practice - Action - Interaction Model</th></tr>
<tr><td>Problem-based Leaning, Challenge-based Learning – Using a mobile computing device, the teacher sends to the students previously created open problems or problems created "on the fly" during the learning session. This material is distributed in real time and can be set either to individuals, to a certain students group or to the whole class. While sending this material, the teacher can still interact face-to-face with the students in order to explain, contextualize and/or clarify the problem the students have to work on.

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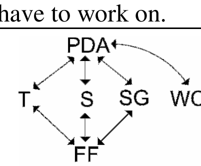
<tr><td>Assessment – The teacher can monitor each student individually or the whole group displaying on his device the workspace of the students. The teacher can physically approach a student or a group in

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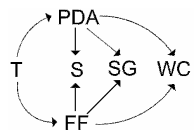
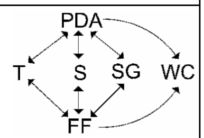
order to give feedback in a face-to-face manner, additionally to using the mobile device to join the workspace of the student or the group at the same time.

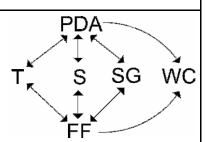
**Peer-assisted Learning, Reflection** – The teacher can select a certain workspace of a student or group of students in order to distribute this to the rest of the class if there is an "interesting solution" which may be a good, or a novel solution or a "near miss". At the same time, the teacher uses face-to-face communication to explain the interesting characteristics of the solution being shown.



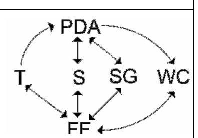

**Challenge-based Learning** – The system gives the teacher to generate and send open questions or "challenges" to the students (individuals or group) during the lecture in three different ways: 1) The teacher can send not fully delimited problems or questions, created on the fly specified by incomplete free-hand drown sketches generated and edited by gestures. 2) same as 1 but the teacher can send along a selection option set to chose the correct answer, 3) same as 1 but with multiple choice option, or 4) same as 1 but sending a sequence of selection (selection of answers in the right sequence). Correspondingly, the answers from the students can be totally open, based on sketches or closed, based on selection. Teacher can use face-to-face interaction to discuss the questions and answers with the students.



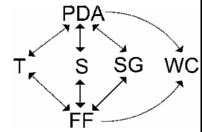

**Coaching** – The teacher can join the workspace o fan individual student or a group of them working together. In this way, the teacher can add annotations and work together living hints for the solution if necessary, complementing this device mediated communication with face-to-face explanations



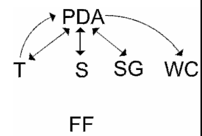

**MCSCL** – The teacher can reconfigure the working groups during the exercise in real time, as well as send new problems in order to put students to work together which best fit together taking in account their background knowledge, working style, personal characteristics, etc. Students belonging to a same group can open a shared workspace and work synchronously. Group reconfiguration is also necessary when implementing the Jigsaw learning practice (Aaronson, 1997) with mobile computer support. Especially during group reconfiguration face-to-face communication between students and teacher and among students




**MCSCL** – Students may have to work interacting with various physical objects disposed in different locations in the room where the learning activity takes place. Here, the face-to-face interaction will also be very helpful among students themselves and between teacher and students.




**Challenge-based Learning** – The interface allows the teacher to create and send material to the students to work on without having to interact face-to-face. Since the material can be free hand created sketches, the teacher can modify them or add new elements to during the learning session thus the original problem can "evolve" according to the performance of the students.




## 4. Description of the MCI-Supporter

MCI-Supporter has been developed to address the pedagogical practices and interactions described in the previous section. The application runs either on PDA and Tablet-PC, automatically adapting the interface in order to fit to the respective screen. It has a teacher's and a students' module. The teacher's module allows them to define groups, assign students to them, create and send problems and asses the students' work by visualizing and joining their workspaces. The students' module allows them to work on their assigned problems collaboratively and send the answers to the teacher.

**Groups' setup:** For creating groups teacher must enter the "Group making" mode of the activity administration utility, clicking the "Create group" icon will create a new "Group sandbox". A group sandbox will represent the common workspace of a group. Each sandbox displays a scaled version of the group's workspace in real time. For every student participating in the activity an icon with her/his name will be displayed. Several sandboxes are shown in the teacher device, allowing her/him to have an overall view of what all groups are doing. Figure 2 shows an example of an activity with 3 group sandboxes.


*Figure 2: Teacher's module, in Group setup mode*

To assign a student to a certain group the teacher may drag participants and drop them over group sandboxes. By clicking on the "Randomize groups" students are randomly distributed to the groups trying to create groups of the same size. Group sandboxes display "participant icons" in order to represent the number of members. When students are assigned to a group, they are notified and a message displays the id of the assigned group. Other group members will be displayed on the student's interface by an icon and the name.

In order to manage students from a group, the teacher must "enter" into a group's sandbox by double clicking it. This will zoom in and display the detailed information of the visualized group, including members' icons with their name labels. Reconfiguration of the groups is always possible by dragging the icon of a student out from the original group sandbox to another.

**Problems management**: Using the "Problem manager" mode, teachers can both create problems, using pen-based sketching and gestures, or load previously created problems. To create a new problem, the teacher must click the "New problem" icon. The system will create the new problem icon, and zoom in, entering the "Problem edit" mode. Teachers can also load previously created problems by clicking the "Previous problems" icon.

**Problem edit mode**: In this mode, teacher can define the nature of the problem. There are two main types of problems: open and closed. Open problems are based on written or drawn instructions, which students will follow once problems are assigned. For open problems, teachers are not required to configure possible answers sets and correctness assessment must be performed manually. For open problems students write or draw a solution.

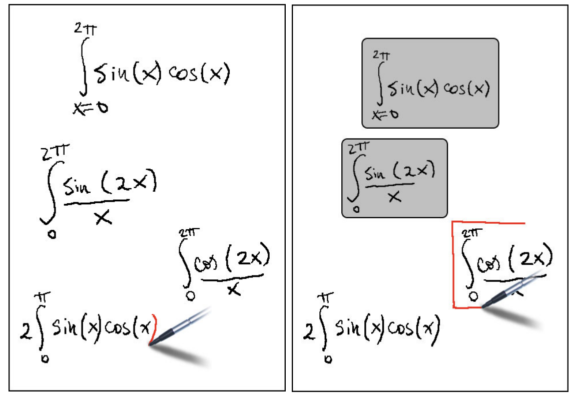


*Figure 3: a) writing the problem definition and the answers; b) delimiting the elements by closing them in rectangles*

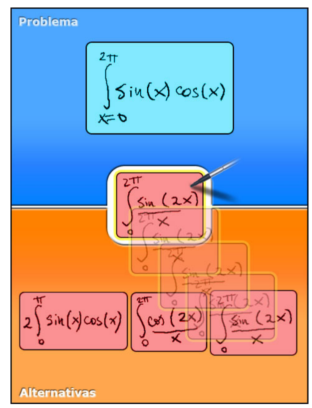



*Figure 3: c) dragging the problem parts into the respective areas*

For closed problems students must chose the right alternatives. There are three subtypes of closed problems: Single answer, multiple answers and sequence answer, (see "Answers assessment" section). Closed problems include a drawn or written description of the problem and a set of alternatives. The teacher defines the correct answer in order to enable automatic assessment (see "Problem answer" section). In order to create a problem's description and alternatives, the teacher must type, hand-write or draw texts and images. A closed problem consists of three parts: the problem description, the right answer and a set of wrong answers. Figure 3 shows this process. On the left the teacher hand-writing the different elements of the problem is shown. The center shows how the elements can be defined and delimited by closing them into rectangles. The rectangle gesture is interpreted by the system as a special instruction. Once parts have been defined, the teacher must drag problem description into the description area, correct answers must be dragged to the solution area (more than one right alternative is allowed) and wrong alternatives must be dragged to the alternatives area.

**Problem distribution**: Once created, problems' icons are displayed in the "problem manager" mode. The teacher can assign a problem to groups by dragging its icon into the group's sandbox. One problem may be assigned to several groups and one group may receive several problems. After the problem is assigned, the teacher may enter the "problem edit" mode to modify it or to create a new version of the same problem.

**Problem answer**: Students visualize problems assigned to their group in their devices in a problem list. A small figure shows if the assignment is pending, it is being worked, it has been completed and evaluated, or is waiting for the teacher assessment (for open problems). In order to answer a problem, students have to double click its icon, accessing the assignment in full screen. For closed problems the problem description is located in the upper region and the alternatives are located in the lower region. The middle zone of the screen varies depending on the subtype, displaying instructions for students. These instructions describe if students must choose a single answer, define a group of alternatives or define a sequence among the alternatives. First, each single member of a group must answer the problem individually, dragging the alternatives from the bottom area into the middle region.


*Figure 4: The figure in the right shows the students must chose an answer by clicking on the "Share answer with group" button. After choosing an answer, the button turns into and agreement indicator (center). Here, the button shows the student's answer coincides with one student but differs from two other. Once all members agree on the answer, it turns into the "Submit answer" button (right),*

**Closed answers**: Closed problems require all members of a group to agree on the correct answer before submitting it to the teacher. Once each student has defined her/his choice she/he must click the "Share answer with group" button, located in the "interaction palette" (Figure 4). As other members chose their answers, coordination lights turn red or green. For each member of the group, a light will turn green when the other student's answers coincide or red if not. Members who have not chosen their answers yet have all their lights off (grey). This tool allows students to coordinate their answers, to encourage debate, and to empower majorities.

**Collaborative answer to open problems**: Open problems allow students to write and draw their solution (Figure 5). Collaboration allows students to achieve a common answer, based on all group members' participation. For these problems students share a common writing/drawing area, where they can build a collaborative solution based on pen-based gestures.

**Submitting Answers**. Once the group has agreed about an answer (using the coordination indicator for closed problems or drawing the answer together in open problems), all members must agree to submit the problem to the teacher. Using the same interaction palette shown in the figure 4, each group participant must click the "Submit answer" button. Again, coordination lights are displayed to represent how many members have agreed to submit the solution. Once all members have agreed about submitting an answer, it is sent to the teacher.

**Close problems' instant assessment**: Because closed problems have defined answers, the system can automatically assess a group's answer to a certain problem. Therefore, as soon as the group agrees to send a closed problem answer, the system checks its correctness and sends a notification to the group. Students can immediately see the evaluation in the problem list

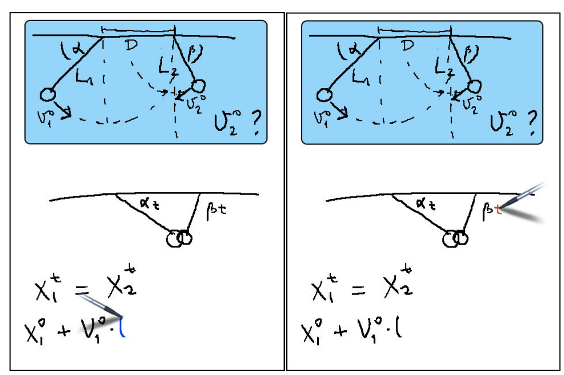


*Figure 5.* Sc*reenshots of two students' PDAs jointly working in the same group work solving different part of a problem*

**Answer update**: As far as an answer has not been submitted students can change their choice for the correct answer. For of closed problems, this would require the repetition of the solution agreement and the submitting process.

**Online-assessments:** As described in the section "Group Setup" of this chapter, the teacher can visualize the current activity of all groups at the same time (figure 2).

This helps the teacher to check whether groups are working correctly, or to find out if any group may need feedback or further assistance. Once the teacher realizes a group needs help, she/he may enter the group's sandbox and input the feed back directly into the current working area of all participants. In this way, Students receive teacher's feedback in real time.

**Activity results**: The Activity Results mode of the teacher's module shows all assigned problems as a table containing reduced views of the answers where the teacher can check all answers at the same time. The teacher can check the solutions to any problem by clicking on any problem preview. Figure 6 shows an example of the activity results table. Tick and cross icons allow the teacher to quickly view the current state of the activity. Clicking again on any problem preview allows the teacher to provide feedback to students.

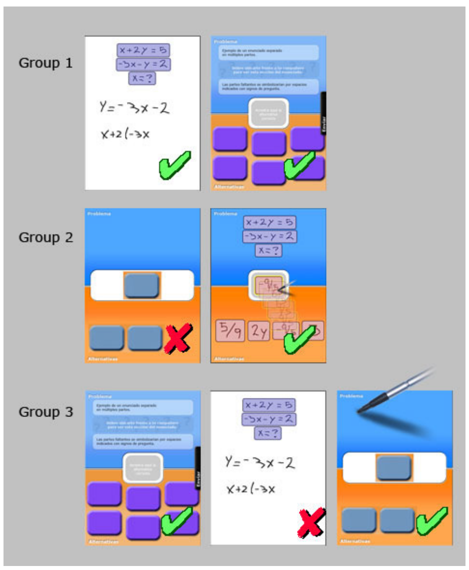



*Figure 6: The teacher' view showing the results mode*

## 5. Mobile add value of the MCI-Supporter

The system has already been preliminary tested in a real scenario. The aim of this testing was to have preliminary results for preparing a larger scale formal testing. During two weeks, 24 students and two different teachers from a pre-graduate university course used MCI-Supporter. The activity was aimed at exercising concepts learnt during course about software development. All type of problems where used during the experience as well as the group reconfiguration functionality. They used the system twice a week in sessions of one and a half hour each. As far as possible, all learning activities described in table 1 were tried. Teacher used a Tabled PC and the students used PDAs.

*Figure 7:* a) *Students belonging to one group working together during the preliminary test*

*Figure 7:* b) *Students during reconfiguration of the groups*

During the activities we could observe high levels of social interaction for all the pedagogical activities. The teacher could easily and swiftly perform the activities of forming groups, distribute exercises and assess the student's work while maintaining the face-to-face communication with them. We also noted that group reconfiguration and inter-group interaction was eased by the fact that they were using mobile devices. We conducted a survey among the students in order to know their opinions about the usability and effectiveness of the system for supporting their work. 67% "agreed" that the system was easy to learn and to use, 33% "strongly agreed". 75% of the students "agreed" that they felt comfortable using sketches, gesture based interaction and overall with the visual metaphor the interface was based on. Another 25% "strongly agreed" with the same sentence. Regarding the effective support the system offered to boost the social interactions 66.6% "agreed", a 16.6% "strongly agreed", and a 16.6% took a neutral position. All students agreed that they felt more motivated to participate in learning activities supported by mobile computing since mobility enabled the face-to-face interactions with other students and with the teacher. Regarding the teachers, both agreed that the system can be applied to any type of content and that its operation is on the whole simple. Some comments from the teachers and the students revealed that the collaborative editing of the sketches was difficult at the beginning and that they had to "learn" how to synchronize themselves. For this, face-to-face interaction was very helpful. They recommended use to improve this part of the system by incorporating more awareness hints.

## 7. Conclusions

The goal of MCI-Supporter is to support a pedagogic style that turns traditional face-to-face teaching into more of a two-way conversation between instructor and student. One of the most important design principles was to combine computer-mediated with face-to-face interaction for a more motivating learning environment. With this design principle in mind, the mobility of students and teacher turned into a requirement, and the problem-based and challenge based learning style was used in order to actively engaging students in the learning process. Although there are other works using also mobile technology to engage students in problem-base learning activities, we can conclude from the literature that this system is unique in the following aspects:

- It is a full peer-to-peer architecture, not using a central server, which allows the system to be used without restriction in any scenario, for example, outside the classroom in a laboratory, a museum, an exhibition to support learning "in the wild".
- Since creation of problems (and its solutions) is based on free-hand writing and sketching input, the system is independent of the subject being taught (as far as the teacher can imagine problems based on sketches and text) and it allows the creation of new problems with open or closed answers "on the fly". During the preliminary test, we saw this feature to be used by one teacher to modify the original problem several times, thus the problem evolved stage by stage to a more complex one.
- It allows the teacher to overview all the workspaces of the groups at the same time. The teacher can choose to give immediate feedback (or proposing a new problem) to any of the groups by joining the synchronized workspace of that group.

Finally, we would like to stress that, although mobile technology represents a big potential for supporting students' learning, they have important limitations. Therefore mobile PDA's based applications must be carefully designed to account for these limitations.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## 10. References


[1] L.S. Vygotsky. Mind in society: The development of higher psychological process, Cambridge, MA: Harvard University Press, 1978.

[2] T. Liu, H. Wang, T. Liang, T. Chan, W. Ko and J. Yang, J. "Wireless and mobile technologies to enhance teaching and learning", Journal of Computer Assisted Learning, 2003, 19(3), 2003, 371-382.

[3] T. Liu, H. Wang, T. Liang, T. Chan, and J. Yang, "Applying wireless technologies to build a highly interactive learning environment", In proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education, WMTE, Sweden, 2002.

[4] A.W. Wright, Teaching Improvement Practices: Successful Strategies for Higher Education, Anker Publishing Co, MA, 1995.

[5] E.A. Skinner and M.J. Belmont, "Motivation in the Classroom: Reciprocal Effects of Teacher Behavior and Student Engagement Across the School Year", Journal of Educational Psychology, 1993, 85(4), 571-581.

[6] D. Suhters, "Technology affordances for intersubjective Learning: thematic Agenda for CSCL", T. Koschmann, D. Suthers and T.W. Chan. (Eds.) Computer Supported Collaborative Learning: The Next 10 Years!. Mahwah, NJ: Lawrence Erlbaum Associates, International Society of the Learning Sciences, 2005, 662-671.

[7] T. Koschmann, A. Zemel, M. Conlee-Stevens, N. Young, J. Robbs and A. Barnhart, "How do people learn? Members' methods and communicative mediation", In R. Bromme, F.W. Hesse & H. Spada, 2005.

[8] M. Anton, "The Discourse of a Leamer-Centered Classroom: Sociocultural Perspectives on Teacher-Learner Interaction in the Second-Language Classroom", The Modern Language Journal, 1999, 83(3), 303-318.

[9] N. Baloian, K. Hoeksema, U. Hoppe, M. Milrad: "Technologies and Educational Activities for Supporting and Implementing Challenge-Based Learning". Education for the 21st Century: Impact of ICT and Digital Resources. Deepak Kumar & Joe Turner (Eds.) Springer, NY, USA, 2006, 7-16.

[10] M.E. Lagos, R. Alarcón, M. Nussbaum, and F. Capponi, "Interaction-Based Design for Mobile Collaborative-Learning Software", Software IEEE, 2007, 24(4), 80-89.

[11] E.F Barkley, K.P Cross, C.H. Major, Collaborative Learning Techniques, Joseey-Bass, San Francisco, 2005.