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# Supporting Field and In-class Collaborative Learning: Towards A Generalized Framework

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***Abstract*— Field activities and collaborative learning are prominent educational approaches. Various devices have been used to implement these approaches. For example, mobile devices have been excellently employed to facilitate outdoor learning, as desktops and laptops have been for indoor collaborative learning. But the use of laptops and desktops for group activities has some limitations like support for limited number of learners who can use a device at a time. Recently, interactive multi-touch tables with shareable interfaces and large displays have reached the market. We propose to integrate all these technologies in a common framework to provide a seamless learning environment providing assistance for learning both indoors and outdoors.**

***Keywords: Mobile learning; Computer Supported Collaborative Learning (CSCL)***

## I. INTRODUCTION *(HEADING 1)*

Research shows that a well planned, effectively carried out and followed up field trip can play a vital role for learners' abilities to understand abstract concepts learned in classroom by mapping them to real life [1, 2]. Technology today provides excellent means to facilitate learning on a field trip in the form of small mobile devices [3, 4, 5, 6, 7].

Another very important research direction is computer supported collaborative learning (CSCL). Research has shown that collaborative learning activities can produce far better results than individual efforts [8]. But, though small mobile devices are excellent for field work, they may not always be the best choice for collaborative learning in conventional class room situations. Some kinds of collaborative activities require technical setups which small mobile devices are unable to provide. Desktop and laptop machines have been used for that purpose. Though they provide a larger display and better processing power, they still have some limitations. For example, they cannot comfortably accommodate more than three members in a face-to-face discussion. Also, there can only be one student at a time that uses the device; the other members can only provide verbal input or feedback.

For face-to-face collaboration with activities such as brain storming and discussion, the most effective way is sitting around a table. And, with all the facilities provided by technology for communication like video chat, voice chat, video conferencing (no doubt these facilities work well when participants are not present in same room), the advantages of simply *sitting around a table* should not be ignored. This setting is comfortable, familiar and fast. When people are face-to-face, they do not communicate through words only. Participants get a better understanding of other people's point of view by their gestures, expression and tone [9].

Today, interactive multi-touch tables with shareable interfaces and large displays are available. Multi-touch tables combine the benefits of sitting around a table and of computer supported learning, but provide some extra features as well. The participants of a collaborative task are not just taking advantage of the face-to-fact setting and a shared view, but multiple participants can provide their input simultaneously or work on different (possibly related) tasks.

## II. LITERATURE REVIEW

In recent years, the main focus of the research in mobile learning has been of the 'field-trip' type. Those field trips could be a visit to a museum [3, 10, 11] or zoo, or some outdoor task required in different subjects for primary, high school or university students. For instance, Wu and colleagues [12] presented a system which helps elementary schools students in learning historical and cultural contents. Other applications designed to help students during field work include [4], a system that helps university students of ethnography to collect data in the form of photos, audio, video, and text notes during their field work and automatically uploads their data to website. An area that has been intensively investigated by researchers of mobile learning is language learning. Considerable work has been done in this particular field. E.g., Wong and Looi [13] have presented a system called MALL that helps elementary school students in learning vocabulary and idioms from English and Chinese language. TANGO [14] is an RFID and Mobile technology based system used for vocabulary learning. Some mobile learning applications focused on facilitating mathematics learning, including a system developed for elementary school students for learning geometry [15]. The approach presented in this paper comprises both outdoor and indoor activities. Other researchers have developed game-based mobile applications to help elementary school students learn mathematics [16].

There are relatively few research papers that report on the use of multi-touch tables for education. Examples include the work of Harris et al [17] who compared the effects of multi-

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touch vs. single-touch on interaction between young pupils while they are working on a collaborative task of seat planning and report that in the multi-touch condition, the conversation was more task oriented as compared to the single touch condition where the focus of talk was turn taking. A game based system called "Futura" designed for collaborative learning using multi-touch tables is presented in [18]. In [19], Rick and Rogers demonstrate the adaptation of a single-user desktop educational system to a collaborative multi-touch table application called DigiTile.

Until now, the research on the use of mobile devices for outdoor learning activities and the use of multi-touch tables for indoor collaborative tasks have been progressing in parallel – an integrative view (which would certainly have benefits for learning sequences that involve indoor and outdoor activities) is missing in literature so far. In this paper, we present such a generic framework, capable of connecting different kinds of devices (including tablet PCs, multi-touch interactive table, and electronic white board) and the advantages that they offer.

## III. MOTIVATION AND REQUIREMENTS

Some important learning concepts and requirements the framework needs to address are categorized in the form of requirements below.

*Ubiquitous Access*: The first and foremost goal for the framework is to provide a truly ubiquitous environment for learning. This way, the main focus of the learners can be on the learning activity instead of thinking about how to switch from device to device and transfer data.

*Usefulness in Multiple Situations*: The key objective of the framework is an effective integration of the various learning scenarios and tasks. The framework should thus provide assistance for learning anywhere anytime.

*Collaborative Learning*: The framework should provide support for collaborative learning, either face-to-face (e.g., using multi-touch-tables) or remotely (e.g., using networked mobile devices).

*Interactivity*: A framework that combines the ubiquitous feature of mobile devices with the shareable interfaces of large multi-touch tables would enhance the interactivity between learners.

*Supporting multiple devices to learner ratios.* For collaborative learning, a 1:m ratio could indeed be beneficial, while for individual learning, a 1:1 ratio may be a better choice. A general framework, which could incorporate multiple learning situations and select device to learner ratios accordingly, will combine the advantages of both ratios.

*Support for Scaffolding*: Scaffolding is a learning mode in which an incremental support is provided to a learner by a teacher, a fellow learner or a machine. Our proposed framework should have an embedded support for incorporating scaffolding through appropriate devices.

*Domain Independency*: One of the major goals for our framework is to build a domain independent platform which should ideally be useful for many school subjects.

*Adaptation*: An important requirement is to offer enough flexibility to adapt available learning tools and material for new technologies like multi-touch tables.

*Support for Everyone*: The framework should be useful for all the participants of class i.e., both students (to fulfill their learning task) and teachers (for designing exercises and learning activities for students and for assessment).

*Immediacy*: The framework would support simultaneous actions and the quick sharing of data, queries and ideas between learners, whether they are a distance observing something worth sharing with their fellows via mobile devices or whether they are working face-to-face.

*Personalization*: The framework would support different cognitive styles of users and it would allow learners to perform some personalization, enabling them to create and manage their own learning resources and to create small learning networks with people with same interests.

*Seamless Communication*: The idea of combining advantages offered by different types of devices in a general learning framework requires a smooth and seamless communication model for all devices.

*Synchronization*: When users are working on some collaborative task using multiple devices, a synchronization of the resulting data across devices should be performed.

## IV. EXAMPLE SCENARIO

A citizenship teacher decided to engage her students in a way so they can develop a better understanding of their community and to appreciate the facilities the community offers to them. So she selects an area of radius 2 km around the school and divides that area between small groups of students. Then she asks the small groups to take a tour through their assigned area with their mobile devices and gather data about all the good and bad aspects of the neighborhood. For example, they need to notice important places, organizations and institute. What are the recreation facilities in that area? What are the major businesses there? What kind of shopping places, health facilities, schools, parks, churches and other institutes are there? They also notice cultural variation, different authenticities and age groups. All such things count as *assets* of the society. During that tour, students are also asked to identify the problems of the community (e.g., maybe they notice many homeless or addicted people in the streets, a neglected park or any other things that they feel need attention). Such things count as *needs* of the society. Students gather their data in different forms. They take pictures, make small videos, talk to people and conduct small interviews, record audio or take text notes, using their mobile devices. Data is saved in *group spaces*.

After coming back to the class, they access their group space at the multi-touch table and transfer their data from the group space to the *public space* by simple drag and drop. Then the teacher asks them to separate assets and needs in two different columns and to arrange them. So students arrange their data in some presentable form. For example, they put all the data (e.g., pictures, videos and text) about a particular park as a single entity in the assets column. They edit their text notes, arrange pictures in some specific patterns and drop some data such as multiple pictures of same thing. They are also asked to add issues in their table of assets and needs that they might not have observed during their trip but has been in their knowledge by other sources.

They also identify the assets and needs on a map of the area by putting marks.

After this, the teacher could engage her students in a discussion about their findings in multiple ways. For example, she asks all her students to put a check mark next to the issue in the needs column that they think is most important (either on the multi-touch table or through their mobile devices). Entries with a lot of check marks are considered high priority. The table is then rearranged according to priorities and students are asked for suggestion how to address the particular prime needs. All suggestions are collected and placed next to that need. A table completed by the contributions of the whole class is transmitted to the students' handheld devices and they select the issue they want to work on, using their mobile devices, with a small description why they select this. The result of this voting is automatically transferred to the multi-touch table as that is synchronized with handheld devices.

Now the teacher puts her students to work more closely, in groups on their selected issues. For example, five students selected a neglected park in the neighborhood they would like to revive, or two students select a patient whom they want to help. And in the assets column, three students select a Chinese community centre they would like to explore more. Now the each issue is discussed one by one. For example, everyone is asked for suggestion how to help improving a particular park. Everyone gives their suggestion (again, either through their handheld devices or through the multi-touch table). All suggestions appear on the table and their feasibility is discussed. After that, a plan is devised and the groups discuss how they will carry on their task for the whole term.

At the end of the term, every group presents the outcomes of their projects. For example, a group working on reviving the park presents how they have helped improve of their parks by showing pictures before and after their projects. At the end of term, students also again mark the map of their area and compare how they have contributed to their society by converting its needs into assets or by reducing the intensity of the needs [20].

## V. STRUCTURE OF FRAMEWORK

Our proposed framework has three essential elements: hardware, a communication infrastructure, and software. We will detail each of these in this section.

### A. Hardware

In our proposed framework, the hardware or devices can be categorized into three following classes:

*Classroom Technology*: includes mainly the devices with large displays and support for group activities like interactive white boards and multi-touch interactive tables.

*Field Technology*: consists of small devices like smart phones and tablet PCs, best for being used in outdoor activities like field work and data collection.

*Home Technology*: includes personal computers like desktops and laptops with their features in between classroom technology and field technology. For example, they offer support for group activities and some mobility, but not as much as offered by classroom technology and field technology, respectively. But their merits (processing power, memory, and adequate view) and availability still requires them to be considered within a generic framework.

### B. Communication Infrastructure

As stated in section 3, a fundamental requirement for our proposed system is a smooth communication between different devices and between users of the system (mediated through devices). Our proposed communication infrastructure can be split into two levels:

*a) Logical Structure:* The system provides a separate space for each curriculum subject which is accessible to the participants of that particular subject (i.e., students and teachers). This logical space is further subdivided into a public space, group spaces, and individual's spaces.

The *public space* is accessible to all participants. The contents of this space can be copied to other spaces (individual's and group spaces), but the access rights for this space will be "read only" for everyone except the creator of the content and the teacher, who could edit or delete content. Open messages, announcements, queries, timetables, and teaching material will be provided in that space.

*Individual's Spaces* are private spaces assigned to every learner. Such a space is accessible to the owner only. She can manage all her data according to her needs and preference. She can copy contents from public and group spaces to her individual space and can also share her data with other individual, groups, or public spaces. The *Teacher's Space* is also an Individual Space with special rights.

*Group Spaces* are the working spaces groups of learners who are working together on some collaborative task. Such a space is accessible to the members of particular group only and they can all create, edit and delete data in their space.

All these logical spaces are stored on a server. Fig.1 shows the logical division of these spaces and their users.

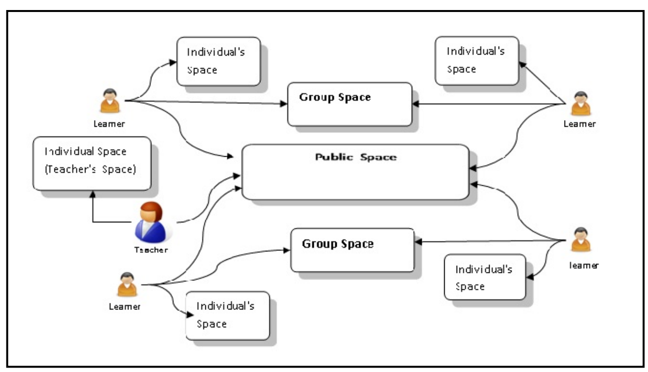


Figure 1. Logical Structure of the communication space

*b) Physical Model:* The logical structure describes the space and rights of the learners and teachers. This seems simple, but one has to account for the fact that there are multiple technologies involved in this framework. Learners may want to access and communicate between these logical spaces while working on different devices. For example, a learner may want to check the next class schedule through his mobile device while traveling in a bus or may want to access her individual space and copy some contents to the group space while working on a group task on a multi-touch table. Leaving all the required data transfer and synchronization between devices and logical spaces on the learner's behalf is tedious for them and constitutes a disruption of learning activities. So there should be some synchronization processes between logical spaces. All the devices used in the learning platform have wireless connectivity in form of Bluetooth, WiFi and 3G. So when learners are in their classroom with their mobile devices with Bluetooth connection turned on, the system will do an automatic synchronization between individual's, group and public spaces via 3G or Bluetooth and as soon as a change is made to these spaces, that would be immediately available to all its users via any device. For example, a group of learners that is working on reviving a park works together to make a presentation of their contributions and improvements regarding their project. They save it on their group space and copy it to their individual's spaces using the multi touch table and then check the same file on their mobile device. Right after that, they will (and should!) see an updated version of the file without any explicit refresh or reload action.

When learners are outdoors for field work or in their homes, the synchronization will be performed through internet via 3G. If a learner loses Internet access due to some reason and makes changes to her data, these changes will be saved on her individual's space and when the wireless connection is available again, the system will synchronize.

An important distinction in the context of all these data transfer activities between logical spaces and devices needs to be made between *synchronization* and *user-intended data sharing*. Synchronization is the process, performed by the system, to keep data up-to-date in different logical spaces regardless of the devices through which it is created or edited. Data sharing, on the other hand, is an activity that a user might want to perform. For example, a learner A from a citizenship learning class notices the opening of a new Chinese restaurant in the neighborhood and thinks that might be of interest for their citizenship class projects, so he takes a picture from his mobile device and sends it to the public space of the citizenship class. Another learner B who is member of the group that is exploring a Chinese cultural centre sees that picture while the group is working together on their project using the multi-touch table and copies that picture from public space to their group space via the multi-touch table. These two data transfers are examples of user-intended data sharing. On the other hand, when the members of the same group access their group space, whether from the multi-touch table in the classroom or from their laptop at home, they will see the same data. That is the synchronization done by the system. The group next sends a thank you message to learner A's individual space (which is also an example of a user-intended data transfer).

### C. *Software*

Software applications to be used within this framework have to consider some criteria with respect to two important factors, *device independency* and *domain independency*. The framework uses specialized technologies for specific tasks. For example, mobile devices would be excellent for data collection but might not the best choice for data manipulation. On the other hand, a multi-touch table is probably never going to be used for data collection in the field but would be superb to be used for collaborative data exploration and manipulation. Some tasks, however, should be doable regardless of the hardware platform, like viewing or sharing data. So, some applications within the framework will be specific for particular technologies (like a toolkit for mobile devices for data collection and a toolkit for multi-touch surface for data manipulation), while other applications would be designed to run on multiple technologies, like reading or sharing files.

In addition to this dimension of device dependency vs independence, the learning contents and tools will differ by subject: for an English class, they could not be exactly same as for geography or citizenship learning classes. These classes will share some common tools like a text editor which will be necessary for all the domains, but a map manipulating toolkit or an equation editor might not be needed in the English class. Keeping these factors in mind, the software to be used within the framework can be categorized into four classes.

*Device and Domain Independent*: Some tasks are common in multiple domains and should be doable through any device like reading text, viewing a picture or playing audio and video, reading messages on a board, or sending messages to other learners or teachers. So application support for these kinds of tasks should be provided on all devices and in all domains.

*Device Dependent and Domain Independent:* This class of applications covers tasks that are feasible for some devices but not for all (like collecting data through mobile devices on a field trip), regardless of the domain, as field work is possible in many different domains.

*Device Independent and Domain Dependent:* This class of software covers domain-specific learning contents and some data manipulation toolkits (like an application for voting in the citizenship learning class or a map reading or GPS data manipulating toolkit for the geography class) regardless of the hardware platform.

*Device and Domain Dependent:* This class consists of tools that are both domain-specific and device dependent. For instance, in a geography class, learners may view a task-specific map through any device, but can only manipulate it using a specific application on the multi-touch table.

Table 1 summarizes some tasks with respect to both their device and domain dependencies.

*Teacher's Toolkit:* In addition of applications as classified by devices and domains, there is another important software function: providing a platform for the teacher to help her develop learning contents, assignments and exercises for students and for assessing student's work. The system must help the teacher adapt existing learning contents and develop new contents also.

TABLE I. TASK CATEGORIES ACCORDING TO DEVICE AND DOMAIN DEPENDENCY FOR APPLICATION DEVELOPMENT

| | **Device Independent** | **Device Dependent** |
|---|---|---|
| **Domain Independent** | • View Data (reading text file, playing audio and video, viewing pictures) Share Data<br>• Communication (Messages, Notice Board,)<br>• Class Schedule<br>• Text Editor | • Data collection<br>→ Taking Photos<br>→ Making Videos<br>→ Recording Voices<br>→ Taking Text Notes<br>• Collaborative Task<br>→ Making Presentation |
| **Domain Dependent** | • Voting<br>• Developing Learning Material<br>• Reading map | • Accessing GPS<br>• Assessments<br>• Working on Map |

Besides all these requirements, a general framework (as proposed in this paper) should be flexible enough to adapt and incorporate new and already existing learning contents, so the system will support for dynamic plug-in of applications.

## VI. CONCLUSION AND FUTURE WORK

In this paper, we described a novel general framework that combines the advantages offered by different state-of-the art-technologies for learning indoor and outdoor. The proposed system (an implementation of the framework) will provide a new kind of ubiquitous environment for both field work and in-class collaborative work, useful in multiple domains, and providing assistance to both learners and teachers. We illustrated the utility and effectiveness of the framework using typical classroom activities and field work scenarios and described a system architecture and main components of the application.

The next steps in our research include an implementation of the framework and first pilot tests with the resulting first system prototype.

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