Applying Sensemaking in a Mobile Learning scenario

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Abstract. In this work, a new type of collaborative learning activity is proposed in order to enable students to explore and understand information in highly mobile situations. We call this "mobile sensemaking" and is based on people engaged in multiple parallel, rapid and ad-hoc interactions, rather than structured decision processes. This activity takes place in a traditional classroom context, thus proposing a new way to design more participative and active "lectures". Mobile sensemaking proposes a proximity model and uses mobile computing devices in order to carry on collaborative activities according to the domain context and physical proximity.

1 Introduction

With the help of appropriate mobile technology and applications, teaching and learning activities are expected to achieve higher levels of engagement, better adaptation to individual and group learning needs, higher learning rates, and better quality of time utilization and a better flexibility of teaching for the instructors. Over the last recent years many systems based on mobile computing technology have been developed for supporting collaborative learning of students in the classroom. Despite of this fact, the basic learning process has remained largely unchanged throughout this time. Many educators agree that the main drawback of the traditional classroom lecture – the one placing teachers as the major focus of attention and most critical resources – is the reduced level of interaction and engagement between teachers and students, and among the students themselves thus negatively affecting the motivation. The limited interaction possibilities in traditional classroom lectures originates a set of problems regarding students' attention and motivation, reduced teachers' awareness of the actual learning accomplishments, and lack of flexibility for handling the necessary adjustments regarding the teacher's and students' goals.

Our endeavor is to improve interactivity in the classroom while still keeping the learning process efficient in terms of resources and time. We have strong reasons to believe that mobile technology provides a technological platform capable to support the levels of interactivity required by the active learning process, and we are building software mechanisms to conserve the teachers' effort in this process. In this paper we show how wirelessly interconnected handheld computing devices may improve interactivity in the classroom involving university students in more sophisticated interactions than those expected in classic lectures, which in turn will foster motivating collaborative learning, [10]. The focus of this technology is to improve information sensemaking in the classroom, i.e. the students' ability to collectively explore and understand information [12] while shifting the teacher's role to the backstage, performing supporting but not coordinating the assigned tasks.

2 Learning environment

Our learning environment considers a common classroom situation where a teacher assigns the task of analyzing a large collection of documents to a large group of students. These documents are related in some way, but the relationships must be discovered by the students through exploration and collaboration. When the task is successfully accomplished, the students should have built a coherent list of topics and identified their most significant relationships, thus defining a strategic view over the proposed research topic, without having every student to read all the documents.

The task enfolds as follows. Each student receives one or two documents from the teacher and is asked to find out the main topics addressed by those papers. This individual task should then contribute to the collaborative effort. Students are expected to share their findings with others, identifying common topics, establishing relationships, and avoiding misjudgments. This should follow in a paced and informal way, avoiding loosing time waiting for individual students to deliver their contributions, and in particular avoiding loosing too much time discussing their divergences as a group. Instead, students are encouraged to engage in parallel negotiations with multiple parties to solve their differences and reach consensus. Overall, the students assume the central role in the decision process, while the teacher is sent to backstage, coaching and encouraging students, assessing their accomplishments, although not coordinating the assigned task. The fundamental aim of this task is to engage students in the sensemaking process. The sensemaking process was proposed by Weick [13] as a primary mechanism for organizations to explore and understand information. Sensemaking is an ongoing process aiming to create order and make retrospective sense about some event or collection of events. It has also been associated to preliminary decision-making activities like "understanding the situation" or "getting the picture" [4]. Sensemaking is also inherently collaborative [8], meaning that the several mechanisms defined by sensemaking (ecological change, enactment, selection, retention) rely on the capabilities of a community of people to identify cues, update and share information, identify possible actions and provide feedback on those actions.

3 Context and Proximity in the learning environment

According to Dey [2], context is defined as any information that can be used to characterize the situation of an entity. An entity is anything relevant to the interaction between a user and an application, such as a person, a place or an object, including the user and the application themselves. In general terms, context is typically the location, identity and state of people, groups, and computational and physical objects.

Dix et al. [3] describe four generic forms of context that influence interaction with mobile devices: infrastructure, system, domain and physical context. Our approach explores one form of context defined by Dix [3]: the domain context. The domain context in our scenario is relatively complex because it combines individual and group work in a very fluid way. Students serendipitously move around the classroom forming temporary groups and holding ad-hoc interactions. The information about when groups were set up, who belonged to those groups and what interactions occurred characterizes the domain context in our scenario. This domain context should be maintained by technology to facilitate sensemaking, since it improves the retrospective understanding of the situation. The absence of domain context would represent an additional effort from the participants, who would have to search endlessly for hints about previous interactions with other students, the common topics that were found and decisions made. We thus believe that the combination of proximity and context is a key aspect for supporting sensemaking in the classroom using handheld computing devices. We define two fundamental types of proximity contexts:

- **Environmental proximity** - The students perform their activities in the classroom. Environmental proximity contributes to define them as a group and to consolidate their expected behavior as group. Environmental proximity is thus associated to the production, sharing and sensing of topics in the classroom.
- **Close proximity** - The students engage together in very proximate face-to-face interactions, to avoid disturbing other students who may be engaged in their own interactions. Close proximity

is associated to a face-to-face collaborative workspace, where two or more students share information and discuss about specific topics, their relevance and possible relationships.

4 Proximity for Mobile Sensemaking

When two or more students are close to each other and wish to collaborate, the handheld computing devices will automatically activate a Close Proximity Context (CPC). The following rules apply to CPC management: a) the CPC is automatically activated when two or more handheld devices are connected together at the very proximate physical level (e.g. using IRDA); b) the students engaged in the same CPC automatically share their workspace and the information belonging to the shared workspace is also part of the CPC; and c) the CPC is automatically deactivated when physical connectivity is lost. Focusing on the whole classroom, we also define an Environmental Proximity Context (EPC): a) the EPC is automatically activated when several handheld devices are interconnected at the physical level (e.g. using WiFi); and b) the students might interact with their devices to request becoming proximate to students for which some similarity has been indicated to them.

Further discussed below according to several situations.

Environmental proximity situation. Teacher and students share the same classroom, and their handheld devices share the same (Wi-Fi) network. Therefore they are potentially engaged in the same EPC. However, not all students are effectively engaged in the EPC at a specific time, because they may be engaged in a close proximity situation . Within the EPC, when a student produces a topic, it is distributed to the other students' handheld devices. The devices compare their current list of topics with the distributed topic and, if there is some similarity matching, the student will be notified. Note that unrelated topics are filtered out, but they may become related later on, when students change their list of topics. If a student wishes to discuss with the student that produced the topic, she will invoke an engagement protocol, which is described next. EPC is useful when the student considers that the face-to-face interactions he/she made so far are not enough and whishes to find out possible relations between her topics and those from other students present in the same classroom. Those students may also include those with whom he/she already had a CPC interaction.

Engagement protocol. First, the protocol requires acceptance from the invoked party. In case of acceptance, the parties must become face-to-face. Since the technology does not identify the students, the engagement protocol must utilize a scheme that does not require identification. The adopted solution involves Hot-Spots: the handhelds requests both parties to move towards a specific Hot-Spots . Hot-Spots are a specific location in the environment . The Hot-Spot selection may depend on load balancing. When students come face-to-face, we have a close proximity situation.

Close proximity situation. The students in this situation are face-to-face and share a CPC. Their handheld devices automatically establish a temporal ad-hoc network connection (IRDA). Furthermore, their devices will provide a shared workspace, where topics may be collaboratively edited and linked with other topics present in any one of the participants' handheld devices. This allows effectively exchanging and sharing topics and links across multiple devices in an epidemic way, whenever students engage in new close proximity situations.

Disengagement protocol. The disengagement protocol occurs when one student considers that the face-to-face interaction is completed, and perhaps other students could be contacted. The disengagement occurs when the student moves away from the face-to-face interaction and the (IRDA) network connection is lost. Then, the student is again in the environmental proximity situation. As mentioned, the contextual information associated to the face-to-face interaction is preserved in the CPC.

5 Description of the Mobile Sensemaking Application

The application delineated in the previous sections has been implemented using a rapid development platform for mobile applications. This platform offers generic support for sketching, pen-based graphical objects manipulation, automatic ad-hoc network establishment, and object distribution and replication, MCSketcher [15], Participatory Simulations [16]. Also, as described in [16], the framework is able to recognize when to users engage in a face-to-face encounter, aligning their handheld devices. In this section we describe how these features were used to build the mobile sensemaking application. Most interaction with these UIs is done with pen gestures, because it is the natural way for a user to control a handheld device.

Paper Distribution. The initial UI allows the teacher to assign papers to each student. On the left part of the handheld screen, a list with student-icons represents all students attending to the activity. This list is populated automatically by recognizing which devices are running the application within the wireless network range. On the right part, a list with document-icons represents all documents available for reading. In order to fill up this list, the teacher may click on the "add document" icon or the "add folder icon," both located at the beginning of the file list. Clicking opens a file browser dialog or a directory browser dialog, loading a single selected file or all documents within selected directory into the list. To assign a paper to a student, the teacher must drag its document-icon over the student-icon. These actions may be repeated several times, assigning multiple papers to a student and multiple students to a paper.

Paper reviewing and topics linking. Once a paper has been assigned, its icon appears in the students' handheld UI. The student may double click any document-icon to trigger the document reader application and view the assigned paper. Document-icons appear in the lower part of the UI, so the rest of the UI is empty and available for writing or drawing topics related to the assigned papers. Once a topic is typed or sketched, the student may link it to one of the assigned papers by drawing a connecting line. When this happens, the system recognizes the gesture and establishes a link between the topic and the paper, represented by an arrow. A topic may be linked to several documents, and a document may be linked to multiple topics. Repeating the "link gesture" unlinks the topic from the document, allowing the student to correct links created accidentally. Also, drawing a "cross gesture" can delete topics generated by the student.

Sharing privileges and information sharing. The system allows students to choose in which way they want to share generated knowledge. In this case, each link may be configured as "public", "face-to-face only" or "private". When a connection between a document and a topic is configured as public, all students in the activity may access such information through the "Topic search screen" or "face-to-face discussion", both described next. If it is configured as face-to-face only, such information will be revealed when two students engage into a face-to-face discussion, allowing the unconfident student to talk about the idea with another participant. When a topic link is configured as private it won't be available to other students under any interaction mode until the student changes its configuration. Students may configure a link access by double clicking it on the screen using the handheld stylus. When this occurs, a small floating palette will offer the three available states that the user can click. Each link between documents and topics displays a small icon representing its sharing configuration. Links are created with "face-to-face only" privileges by default.

Related topic search and environmental sharing. As described in section 4, the activity encourages students to interact either in close proximity or environmentally. Students may access all knowledge generated by others configured as "public" by their authors. The "topics map" screen displays a diagram where every student is represented by his/her icon, including the current user centered in the middle of the screen. Each student icon is surrounded by its public topics, in a star diagram fashion. Smart text matching algorithms simplify the search process by organizing the topics map according to the student's interests. Topics similar to the current student's ones are displayed closer to the center, drawn in darker color if their similarity reaches a high level. The participant distribution in the screen depends on overall topics likeness: other students may be located near the center when they have a high number of coincidences between his/her topics and current student's ones.Originally, the screen is zoomed in order to display the closest participants only. The user can drag the screen to navigate through the entire list of participant holding and dragging the stylus. Also, the user may zoom in or out clicking the magnifier icons or dragging the zoom slider at the right of the screen. Finally, the user can double click another student's icon when he/she is interested in this particular student's topics or wants to invite him/her to a face-to-face encounter. Based on these simple pen-based gestures each student may browse all public topics.

Interacting with other students. Students enter the interaction screen by double clicking another participant icon in the "topics map" screen or engaging in a proximity face-to-face interaction. The first alternative allows a user to interact in an independent and one-way only, and the second one establishes a two-way interaction. In the interaction screen, the lower region of the screen belongs to the current student, while the upper region corresponds to the other user. The icons of documents assigned to both students are displayed beside the students' icons. These files icons may be double clicked triggering a secondary reader application, as mention before. Also, such icons are surrounded with their topics and their links to the documents. In case the interaction is triggered by a face-to-face encounter, all links configured as public and as available in face-to-face interactions are shown. When the interaction is activated from the "topics map" screen and the other student is not in front of the current user, only public topic links will be displayed. A student may manually link his/her topics with the other students'. To create a link between two topics he/she has to draw a line connecting their labels, in the same way as he/she linked the topics with the documents in the topics definition screen. Topic to topic links show an arrowhead according to which student created it. In case both students agree on such relation, having the two of them drawn the same link, the line will have arrowheads in both ends and get highlighted. Automatically created links always display as a two-way link. Finally, students may link their documents directly to the other users' topics. Topic-document's links are created using the same link gesture available in the "topics definition" screen. By doing this, topic label will be relocated in the center of the screen, showing its links to documents of both students.

Engagement invitation. A student can invite another participant to take part in a face-to-face interaction, in order to access to his/her "face-to-face only" topics and links. Invitations are generated in the interaction screen drawing a line between both students' icons. This will show a dialog which allow the students to make a *rendezvous* appointment in a certain a hot spot. The invited student will get an alert in his/her device inviting him/her to meet in the appointed location. Such alert has a "dismiss" icon, which will cancel the invitation. In this case, the first user will be notified of such response. In case the invited student accepts the proposal, both participants will meet in the assigned place and start a face-to-face interaction, as described before, entering the interaction screen.

6 Discussion & Conclusions

The use of handheld computers to support learning has attracted the attention of many authors. Among the earliest works we can cite is described in [5]. More works are described in [14] and [9]. In all cases, the reason for having mobile devices is to support the social face-to-face interaction and to achieve high levels of activity in the classroom, avoiding passivity of the students. The importance and potential of context in general and awareness in particular was discovered very early in the short history of the development of collaborative mobile applications. In [6] the author presents a works showing how context information can be used in different application areas, e.g. tourist guidance, exhibition guidance, e-mail, shopping, mobile network administration, medical care and office visitor information. In these studies, the location of the user is the main attribute used in the context-adaptation. In [1] the authors show the value of context information and social awareness for developing an application to support collaboration between experienced and novel doctors in a hospital. In [11] a mobile application which offers various services supporting office-type work which uses context-awareness, mainly information on position of the user and available services nearby. It seems there are no major contributions in the field context-aware applications for supporting collaborative learning except for those dealing with participatory simulations, like the one described in [7]. In this work, we apply the theoretical framework proposed by Dix [3] to develop a model and a whole-classroom collaborative learning application. We think this model an application can also be applied to other scenarios beside the described in section 2 where the common element is that the information about proximity between users can be used for having a context-aware application. Some of these scenarios may be conference participants using handhelds during the conference to ingress a list of topics reflecting their research interests, a small group of employees performing teamwork in an ad-hoc setting (e.g. emergency management), but they do not know in detail the responsibilities and activities of their colleagues, or any kind of activities with people doing field-work having to exchange information among each other in a reduced surrounding.

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