

Using Mobile, Collaborative Computing Technology to Support Learning Signal Propagation Modeling

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ABSTRACT

Teaching and learning the principles of wireless communication is a challenging issue mainly because it is difficult for students to translate the theoretical models that are commonly used in this area into practical knowledge. In order to address this challenge, we explore how to design and implement novel teaching and learning activities that integrate the principles of situated learning supported by mobile, positioning and web technologies. In this paper we present the results of our on-going efforts in this direction describing the rationale of our approach, an application supporting a learning activity designed under this approach. The proposed approach offers the students new possibilities to combine theoretical and practical knowledge in a variety of collaborative situations in which mobile and web technologies played a central role.

Keywords

Computer supported collaborative learning, Signal propagation modeling.

1. INTRODUCTION

Many scholars agree that teaching and learning wireless communication is a challenging issue mainly because it is difficult for students to translate the theoretical models that are commonly used in this area to explain the propagation of the signal into explicit, practical knowledge [4, 5]. This knowledge is essential order to be able to plan wireless networks settings, which is a fundamental activity for this area. From a pedagogical perspective, situated learning offers an interesting framework to support the translation of abstract, theoretical knowledge into concrete skills by applying knowledge in realistic settings [10].

In wireless network planning, engineers must determine the location of a set of transmitters (antennas) and their characteristics, like transmission power, frequency, direction, etc. in order to cover the area using the minimum of resources [3]. In order to do this, engineers normally use software, which simulates using mathematical models the propagation of the signal emitted by a transmitter. Various models simulate the propagation under various landscape conditions (urban areas, sub-urban areas, mountainous areas, flat countryside areas, etc.) [1,2,6]. Choosing the right model for each situation is not an easy task because some scenarios may combine various landscape types at the same time. Therefore, planning the network requires performing real measurements at various locations in order to check if the applied model predicted the propagation correctly or correct the assumptions.

Situated Learning theory recommends that students perform these modeling activities in a real environment with the help of an expert and having the opportunity to reflect about the learning experience. Collaboration is also considered by the

situated learning to be an important aspect that should be present in this process.

In this paper we present a learning support tool implementing a learning methodology which includes various learning activities taking place in different scenarios in and outside the classroom, supported by mobile and web technologies and applications.

2. SITUATED LEARNING THEORY

Situated learning states that learning requires theoretical concepts learned inside the classroom to be linked to practical situations in authentic contexts where they can be applied [7]. According to [8, 9], the way in which humans learn implies practicing the concepts acquired in theory. Vygotsky [9] explains that teaching and learning activities involving conceptual knowledge (learned inside a classroom) and practical implementation (in real situations) are not only complementary, but also feedback each other in a process of ongoing and increasing interaction. According to [11, 12], situated learning needs to be intentionally intensive and explicit in the proposed curriculum.

Recent advancements in mobile, wireless and positioning technologies, combined with contextual computing, provide an opportunity for curricular development that may take advantage of these devices for supporting different aspects of learning and teaching [16]. Mobile and wireless technologies allow interaction with the real world in new ways because computational power and interaction are available outside the classrooms limits. According to [11], mobile technologies, combined with content access virtually anywhere and anytime, allow learners to gain new learning experiences in a variety of situations beside the classroom itself [12].

Context information such as the user's location and/or his or her activity/task and his or her profile can be crucial to enhance the users' experience and the collaboration modes in which learning activities occur [13]. Adding location and context awareness to these new artifacts increase their usability and offers new ways to the user interaction and experience [14].

In order to make situated learning applications theory operational, [8] identify the critical aspects of situated learning which enable it to translate this theory into practical teaching methods. In response to this challenge, a practical framework for designing learning environments was produced [15] with the following components:

C1. Authentic context. A situated learning environment provides an authentic context that reflects the way knowledge is used in real-life, preserving the full context of the situation, which invites exploration and allows for the natural complexity of the real world. In the context of wireless network planning learning students should feel they acquire the knowledge needed to perform this task in a real scenario.

C2. Authentic activities. A situated learning environment provides authentic activities which are ill-defined: students find as well as solve the problems. Wireless network planning is a rich scenario where unforeseen problems arise and where a theoretical “perfect” solution might be impossible to implement.

C3. Expert performance. Situated learning environments provide access to expert performances and the modeling of processes, allowing students to observe the task before it is attempted. Such access enables narratives and stories to be accumulated, and invites the learner to absorb strategies which employ the social interaction and participation. Studying wireless network planning envisages a rich modeling process as well as practical work with professional tools students have to master.

C4. Multiple roles and perspectives. Situated learning provides learners with opportunities to investigate multiple roles and perspectives of the activity being performed. In the wireless network-planning context there are at least two roles that provide different perspectives of the problem.

C5. Collaboration. A situated learning environment supports the collaborative construction of knowledge as well as knowledge sharing. Collaboration and information sharing between the various role players in wireless network planning is fundamental to accomplish the task.

C6. Reflection. A situated learning environment promotes reflection to enable abstractions to be formed. This is important in order to allow the knowledge being acquired in the context of the particular learning activity being performed to be used in a different scenario. Since the study wireless network planning has a theoretical as well as a practical side reflection is needed to couple both perspectives.

C7. Articulation. A situated learning environment promotes articulation to enable tacit knowledge to be made explicit. This is in close connection with C5. The need of communication and knowledge sharing between the various members of a wireless network planning team encourages them to transform their tacit knowledge into explicit knowledge in order to share it.

3. THE LEARNING ACTIVITY

The design and deployment of large-scale wireless networks consisting of various antennas providing a certain area with service, using minimum resources constitutes a real engineering activity actually performed by professionals of this area. This process has 3 stages: planning, implementation, and evaluation.

The planning stage is performed using cartographic information about the area which should be covered with the signal emitted from the set of antennas, and using a signal coverage simulation tool. This activity consists of locating a set of antennas and simulating the area covered by them using available simulation software. Normally, software of this kind implements various electromagnetic signal propagation models and allows the user to choose which one to utilize in each case.

The implementation stage consists on building the network of antennas based on the planning stage. Finally, the evaluation stage consists in measuring with real instruments which is the actual coverage of the signal by taking samples of the signal strength in various geographical strategic points. The information obtained from the measurements is gathered and contrasted with the data obtained by the simulation during the planning stage in order to make the necessary adjustments to the network for obtaining the desired results.

Starting from the described activity taken from the real-life, a learning activity was designed based on the Situated

Learning theory, which mainly consists in carrying on the evaluation stage. For this, we defined two roles: planner and measurer. For each role a specialized tool was developed in order to support their activities (see section IV).

The learning activity envisages two sessions: the first one is the theoretical session where students learn in a classroom setting the various existing models for simulating the signal propagation. During the second session a practical workshop is performed which starts by defining working groups consisting of four students each. Two of them take the role planners and the other two the role of measurers. The tasks to be performed are also divided into two stages: the first one is the input of data stage and the second one the evaluation stage.

During the input of data stage planners will make a signal coverage analysis for a set of existing real antennas using a signal coverage simulation tool (see Fig. 1) and a collaboration tool (see Fig. 3). Both tools have two different interfaces implemented, one designed to be used on a desktop PC and the other to be used on mobile devices (see Fig. 2). Students get the necessary information about the antennas in order to perform the simulation like the geographical location, height, strength, radiation pattern, etc. This information is used to feed the signal coverage analysis software which actually performs the simulation after students choose the propagation model they consider is the most adequate given the cartographic information provided by Google Earth. Once the simulation is performed and simulated data about the signal strength for the whole area is obtained students receive a set of coordinates of various geographical points, which they have to input into the collaboration tool along with the data about the simulated signal strength for each of these points.

During this stage the measurers have to go to the places designated by the coordinates, which were given to the planners. At those places, measurers use professional signal strength tools to obtain the corresponding information of the real signal strength at that location. Then, they input this data using the collaboration tool in order to share it with the rest of the team.

During the evaluation stage, planners and measurers work using a collaboration platform we have developed (a detailed description is provided in the next section) in order to find which is the model that better predicts the real measured value of the signal strength by comparing both data: the simulated and the measured. However, students will realize that there is no single model, which predicts the real value for the whole area. The actual learning occurs when students have to justify the reason for this, by checking the different geographic and building scenarios in site. The system allows them to input and browse the simulated and real data in order to compare them and start discussion.

4. SOFTWARE AND HARDWARE

As mentioned in the previous section the software consists of two applications, one for each role. These are the coverage analysis tool for planners and the collaboration tool which is used in both steps by both roles. The first one was already developed for the previous work reported in [14] for supporting a learning activity for a single learner scenario. The collaboration tool interacts with the coverage analysis tool and was developed in order to enhance the learning experience by including the collaborative learning activities in the way the Situated Learning theory recommends.

3.1. Coverage Analysis Tool

This tool has two interfaces, one for desktop computers and another for mobile devices. The desktop interface supports

the planning activity in the classroom which includes performing simulations and storing the generated data. The mobile interface is designed to provide the simulation data while working on the field.

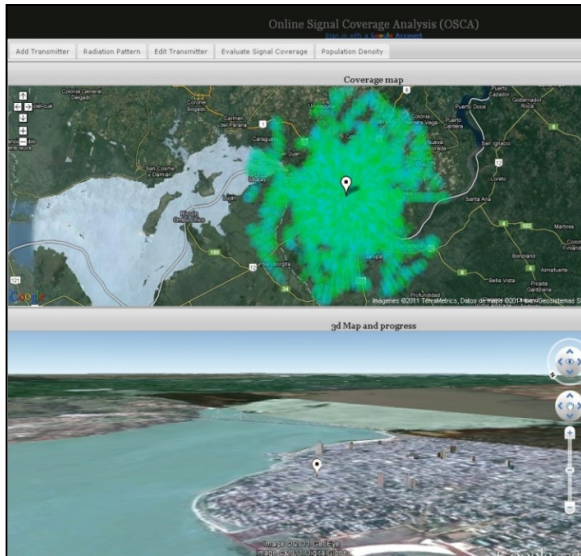


Figure 1. Coverage analysis tool on desktop browser with the 2D (up) and 3D (bottom) views. The white marker on both views represent the location of the antenna. The light green area of the 2D view corresponds to the area covered with signal according to the simulation model.

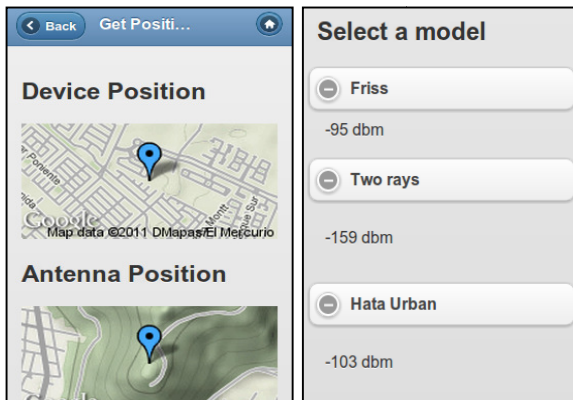


Figure 2. The picture on the left shows the upper half of the mobile device's interface. The map on the top shows the student's current position according to the device's GPS. The map on the bottom shows the antenna's location. On right, the bottom half of the interface shows the signal strength values according to each available model is displayed.

The Desktop interface has four main features:

- Add Transmitter:** The goal of this feature is to provide an easy way to perform the planning step, using a 2 and a 3 dimensional map. The 2D map is used to specify an approximate location of the antenna. This map is synchronized with the 3D view (see Fig. 1). After this, the antenna can be set with a double click on the 3D view. Then, the technical specifications of the transmitter can be filled in a pop-up form (not shown in Fig. 1), which include the propagation model to be used in the simulation.
- Edit a transmitter:** In order to allow students to test different models, the specifications of a transmitter can be edited.
- Radiation Pattern:** Each type of transmitter has a specific radiation pattern, which defines the transmission power on a specific direction. This is an important parameter for simulating the signal strength.
- Evaluate the Spatial coverage:** This function performs the actual simulation by computing the signal strength in the

whole area by applying the selected propagation model for that antenna.

The Mobile interface allows students to retrieve the simulated signal strength values at the current location according to all available models while students are working on the field. First, the Select antenna function should be performed in order to choose the antenna from the available set according to which the signal strength should be computed. Then the GetPosition button should be pressed in order to let the system retrieve the current position of the student with the mobile device using the GPS of the mobile device. Then the system shows the simulated signal strength emitted from the selected antenna at the device's position according to all available models. Figure 2 illustrates the system's interface for the mobile devices. At the right-hand side the simulated signal strength according to the available models is displayed. At the left hand side the mobile device's position (where the student is currently standing) and the selected antenna position are shown. By clicking on the button labeled with the model's name, more information about the simulation results is displayed.

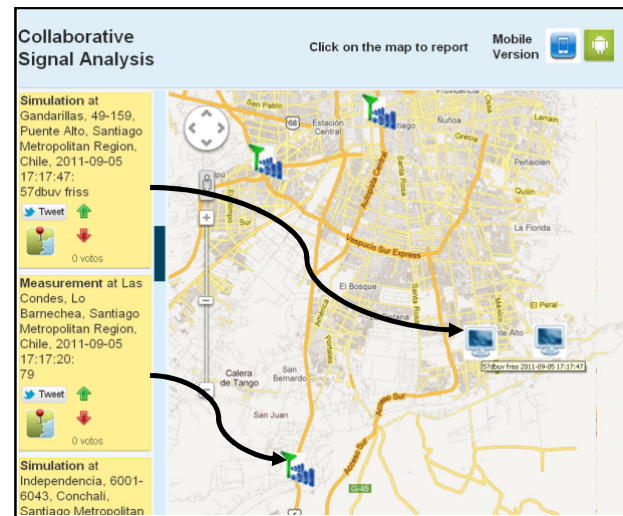


Figure 3. The desktop web browser interface is used to input simulated or measured signal strength values for various locations. For this the user clicks on the map and enters the information. Screen icons indicate a simulated value for that location was inputted, antenna icons indicate a measured value. On the left column, detailed information for each data on the map is shown.

3.2 The Collaboration tool

This tool has also 2 interfaces, one for desktop and another for mobile devices. The desktop interface is used during the planning activity in the classroom and the mobile is the collaboration tool which is used on the field while students are measuring the signal strengths. The desktop version has 2 features: report a simulation value, and vote for a measurement or simulation. The mobile has 3 features: report a measurement, and vote for a measurement or simulation.

Report a Simulation (on desktop version only): Students publish the simulated signal strength for a certain location. The goal of this procedure is to have the values available for the evaluation step, in order to allow students to compare this value with the measured one (see Fig. 3).

Vote (available on desktop and Mobile versions): During the evaluation step students have to choose the most adequate model to predict each measured value of the signal's strength. While planners have better information about the simulation results and the geographical characteristics of the area between the antenna and the device position, measurers

have on-site information about the local conditions for a certain point. Both actors can use the voting system to express their preference for one model or the other according to their information.

Report a Measurement (on mobile version only): This functionality allows students on the field (measurers) to publish measured values to the rest of the group (other measurers and planners). The measurer first obtains the signal strength with a measuring device. In order to publish this value the button labeled with Signal should be pressed, then the value should be typed in and the Report button pressed. The system automatically adds the location information using the GPS feature of the mobile device and shows it on a map.

5. CONCLUSIONS

The learning of wireless network planning is a difficult task due to the fact that it requires a non-trivial theoretical background as well as practical experience in order to understand a problem, which is in most cases ill defined. It is therefore important that the students have the opportunity to face the wireless network planning process in conditions as close to the real situation as possible. Based on the situated learning theory, we developed a learning activity and the necessary computer technology to support it, which allows students to have an experience that helps them to realize many of the most important challenges and problems of this process. Compared with other efforts reported in the literature, the work presented here goes one step forward as it envisages a combination of in-classroom theoretical learning sessions with laboratory and on the field work. It also encourages collaboration and reflection.

We performed an experiment with engineering students from a course about digital communication systems in order to evaluate if the principles of situated learning were correctly applied and if this specific activity did introduce an added value to the learning process.

The experiment was performed by 28 students, divided into seven groups of four participants each. Two of them took the role of planners and two the role of measurers. The activity was performed after having the theoretical sessions in the classroom explaining signal propagation and their simulation models as well as the practical sessions in the laboratory where they learned how to measure signal strength with special equipment. In the first step of the experiment, planners ran the simulation software calculating the theoretical signal strength values using all models for a pre-designated area in the city where the university is located. Simultaneously, measurers went to pre-defined locations to measure the signal strength. The locations were strategically chosen by the teacher for being easily accessible and also having interesting conditions for studying the signal propagation phenomena, like being located near hills or group of buildings, which will challenge the simulation results as these elements introduce local variations in the propagation pattern.

For performing the second step of the learning activity which corresponds to the discussion of the results, students were given three days in order to compare real and simulated signal strength values, comment about the differences they found among them and trying to explain them. After this they presented the conclusions to the teacher and the rest of the class.

Results from the experiment tend to support this assertion, since the results of the questionnaire answered by students after the experiment show high degrees of agreement with assertions related to these aspects.

The activities and results described in this paper contribute with new insights and perspectives related to the design of

situated learning activities using mobile, positioning and web technologies. The outcome of our efforts provides some indications that well designed learning trajectories with solid theoretical foundations can successfully combine outdoor group learning experiences with learning activities in the classroom to provide learners with meaningful activities in order to learn and to explore a complex topic in authentic settings, reason and to argument in order to come to the solution of a problem, collaborate in order to construct common knowledge, and visualize and reflect upon relevant matters and to support complex thinking.

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