A new Systemic Methodology for Lab Learning based on a Cooperative Learning Project

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Abstract—**The idea of this paper consists of developing a new methodology based on a complex system that will be analyzed and programmed by several groups of students that must work openly and cooperatively to achieve a final global result. For this purpose, a personal digital assistant developed as an open hardware called OpenMoko has been selected. The paper details the experience of working with this system and highlights the main obtained benefits.**

Keywords-systemic methodology; cooperative projects; open hardware; lab learning;

I. Summary

Cooperative learning (CL) is a successful teaching strategy based on the constructivist theory of learning in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject [1], [2]. Usually, learners are divided into different groups so that they can discuss and share their work with each other during the learning process to increase the efficiency and quality of their learning. One of the main benefits of cooperative learning is that learners can improve their ability in the subject and learn to adjust their interpersonal relationships through interactions with other group members [3]. In cooperative learning situations there is a positive interdependence among students' goal attainments; students perceive that they can reach their learning goals if and only if the other students in the learning group also reach their goals [4]. Cooperative learning must be distinguished from group work. Although cooperative learning does employ groups (actually teams), group work is not necessarily cooperative learning. The main differences of Cooperative Learning (CL) respect to small-group discussions and group projects typically used in Higher Education are the selection of group members on the basis of predetermined criteria which have been deliberately designed to potentiate the positive effects of small group learning, the continuity of group interaction, the interdependence among group members, the explicit attention to the development of social skills, and the role of instructor as a facilitator [5].

On the other hand, project based learning (PBL) is an educational teaching and learning methodology that has been actively used for some time now. Project-based learning is grounded in general theories of knowledge such as situated learning [6], which states that knowledge must be presented in an authentic context, using settings and applications that would normally involve that knowledge, and includes social interaction and collaboration to solve complex problems [7], [8]. When compared to traditional lecture-based or teacher-centered engineering curriculum, the PBL model appears to inspire a higher degree of involvement in study activity [9]. In this case, PBL should not be confused with problem-based learning. The main difference is that in project-based learning, students mainly apply previously acquired knowledge and the production of some final product is the central focus of the assignment. By contrast, problem-based learning students have not previously received formal instruction in the necessary background material and the solution process is more important than the final product [10], [11].

This paper proposes the combination of both concepts in an electronic lab subject using a complex system over which groups of students can develop partial works. An open hardware project called OpenMoko has been chosen as the complex system in which both learning strategies are developed. Openmoko™ is a project dedicated to delivering mobile phones with an open source software stack. The Openmoko stack, which includes a full X server, allows users and developers to transform mobile hardware platforms into unique products. The license under which is released gives developers and users freedom to cosmetically customize their device or radically remix it.

II. Methodology Description

The proposed project consists of building an application for an Openmoko phone able to connect to a beacon (implemented in a PC) which provides information pages through a Bluetooth link. These pages are very simple and can contain texts, menus and sounds. Due to the complexity of the project, four subgroups were created:

- Subgroup 1: Bluetooth. The objective of this subproject consists of managing a Bluetooth link between OpenMoko and the Pc beacon.
- Subgroup 2: Graphic Interface (QT). This subproject consists of working with the QT framework to develop a graphic interface.

- Subgroup 3: Audio Interface. Mplayer software is used to play both local files as well as the audio information transmitted by the beacon.
- Subgroup 4: Accelerometer. The embedded accelerometer is used to recognize some movements and perform some actions depending on the detected movements.

The global project is specified in detail. Consequently, each subproject must develop its own tasks but taking into account the activities and interfaces with the rest of subprojects working with the OpenMoko system.

In the first few sessions the teacher explains some introductory lessons about the GNU/Linux operating system, the Openmoko platform and the development tools. In order to facilitate the work both inside and outside the classroom, the teacher created an image of a GNU/Linux distribution with the toolchain installed so that the students could use it by simply installing an open source virtualization platform. In this way students can work in their own PCs with the same environment without having to change their O.S. or spend time installing the toolchain and setting up the environment.

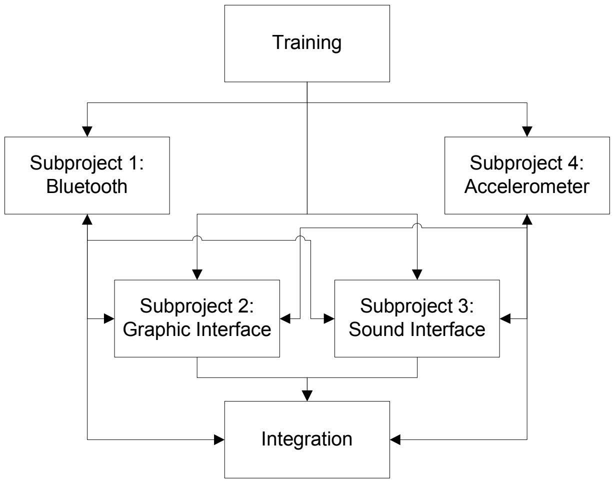

Figure 1. Stages of the methodology and subprojects relationships.

The following sessions were dedicated to the project's development and they were divided in three stages, Figure 1:

- Stage 1: Training. In this stage students must study the technologies and tools related with their subproject, and they must perform small test programs.
- Stage 2: Modular design and specifications. First, the particular specifications of each subprojects are defined, working in a coordinated manner with the rest of groups. Necessities are analyzed and specifications are agreed to guarantee the compatibility of the modular developments performed by each group. Second, each individual project is launched and developed.
- Stage 3: Integration. All the individual projects are joined together, making the necessary corrections to achieve the required main functionality.

During the development of individual subprojects, the first minutes of each class were devoted to follow-up reviews. Then, the self-learning of the group and the utilization of previous knowledge and skills of each group member are promoted.

III. RESULTS

The obtained results by each subgroup are next detailed:

Subgroup 1: Bluetooth. The students managed to establish a connection between the Openmoko phone and a computer by using Bluetooth's SDP profile and RFCOMM protocol. The SDP profile was used to publish the specific service so that the devices belonging to the system can connect between them without bothering devices that do not belong to the system. For the data transfers, the students used the RFCOMM protocol, since it provides a serial-like link. They also designed a specific application layer protocol intended to be run on top of RFCOMM, Figure 2. This way they can send easily simple files describing the data that should be displayed on the Openmoko terminal.

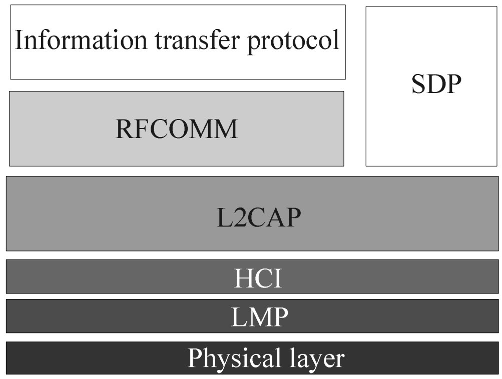

Figure 2. Protocols of the Bluetooth link.

Subgroup 2: Graphic interface. The progress of this task was slower than others due to some problems the students had to face, but finally they managed to build simple windows on demand, at runtime, using QT as the framework for developing the graphic user interface.

Figure 3. Graphic interface.

Subgroup 3: Audio interface. This subgroup built a basic sound infrastructure based on mplayer that was able to play both local files and streams. This infrastructure is intended to be used together with the Bluetooth module in order to play the incoming streams from the beacon (PC).

The designed sound interface uses the sound infrastructure and certain audio applications that are installed in OpenMoko phones, adapting them to fit our application requirements. These needs are focused basically on playing OGG/Vorbis compressed audio streams which are received through the Bluetooth connection. The group assigned to this subproject managed to create programs that played audio streams by using ALSA and Mplayer. In order to accomplish this, they launched Mplayer in command mode and created a pair of pipes (FIFOs), one for sending the audio stream and the other one for sending commands. The sound interface is able to launch on demand several Mplayer instances running in background simultaneously. They also made some tests to integrate a text-to-speech program (Festival) within the sound interface and managed to generate little audio chunks and compress them in OGG/Vorbis format. This group even defined the API functions necessary to control the interface. They implemented these API functions as a library (libsui.a) which can be linked to any application using the sound interface. The set of functions that control the audio player were implemented as an independent program running in background (suid),, Figure 4.

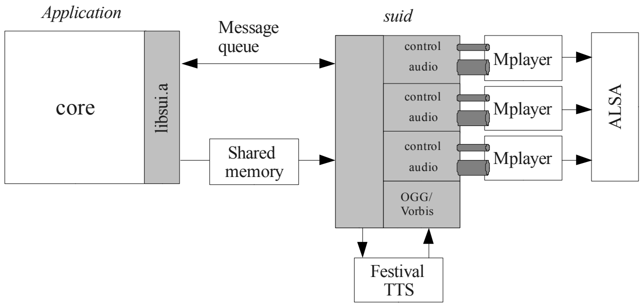

Figure 4. Audio interface scheme.

Subgroup 4: Accelerometer. The students managed to retrieve the accelerometer's data and do a simple post-processing on the data to detect certain movements. In the third stage this events are reported to the main application. This way, the user could change the selected item in a menu by simply moving the phone.

Integration. The previous subprojects have been integrated in a final application where the human machine interface is solved making use of hand movements. Whenever the phone is moved up-down-left-right, the cursor is accordingly moved. This way the final user can visualize incoming information or play incoming audio streaming. The integration stage requires the different subgroups must negotiate common interface specifications.

IV. PEDAGOGICAL EVALUATION AND BENEFITS

To analyze the pedagogical value of the proposed lab learning methodology, we must first corroborate that we are indeed developing the mentioned cooperative and project based learning.

The key pedagogical assumptions of cooperative learning are: (i) knowledge is created as it is shared. Therefore the more students share information the more they learn; (ii) that learner's have prior knowledge they can contribute to the discussion; (iii) that participation is critical to learning and; (iv) that learners will participate if given optimal conditions [12], [13]. To accomplish these premises, groups must work together and members should solve problems by a process of discussion and interpretation of results. Participation is encouraged because groups should evaluate themselves at the end of the course indicating the degree of involvement of each member. Participation is one of the main antecedents of information sharing [14][15], and knowledge sharing allows the creation of new knowledge through a process of knowledge revealing, knowledge reusing and knowledge recombination. The use of prior knowledge is also promoted with an intentional group formation. Groups are formed trying to merge different students' profiles in terms of previous knowledge and previous curriculum. Finally, students have available all the technical resources, including documentation, lab equipments, and the complete framework for working with OpenMoko

On the other hand, PBL has also several premised that should be accomplished. Some authors [11], [16] takes a broader approach to defining PBL, offering five criteria that a class project must have in order to be considered an instance of project-based learning. The project must be (a) central to the curriculum, (b) focused on questions or problems that drive learners to encounter and struggle with the central concepts and principles of a discipline, (c) a constructive investigation or goal-directed process that involves inquiry, knowledge building and resolution, (d) conducive to student autonomy, choice, unsupervised work time, and (e) realistic, focusing on authentic challenges where the solutions have the potential to be implemented. All these premises are also considered in the proposed methodology. OpenMoko is an open hardware intended to perform developments directly related with a lab learning activity. The course organization also pursuits a constructive approach, promoting the discussion, the searching of solutions and alternatives, and improving the students autonomy when facing a new and unknown problem. Finally, the integration stage guarantees the result is realistic because it is finally implemented.

The main benefits of CL have been highlighted in [17], where they analyze 120 studies to compare the relative advantages of cooperative, competitive, and individualistic learning on individual achievement. The results show that cooperative learning promoted greater achievement than competitive or individualistic learning methods. The research also found that cooperation promoted greater intrinsic motivation to learn, more frequent use of cognitive processes such as re-conceptualization, higher-level reasoning, meta-cognition, cognitive elaboration, and networking, and greater long-term maintenance of the skills learned. At the end of the course, it was checked that students' motivation was improved. They exhibit a high degree of involvement if their tasks. In particular, the integration stage was valued as the most exciting and interesting phase of the project development.

The main benefits of project based learning are listed below:

- Students develop skills and competences like collaboration, project planning, decision taking, communication and time management.
- The learning process is linked with real life, and this issue contributes to improve knowledge and skills as students are more involved with the project.
- Development of collaborations skills to build new knowledge. Student must share ideas, and then discuss and negotiate solutions.

The work with OpenMoko is clearly linked with the field of mobile phones applications. The use of Bluetooth and accelerometers are linked with emergent technologies and students feel strongly motivated for this kind of tasks. The course organization as subprojects integrated in a global big project makes necessary not only the collaboration between group member but also the discussions and negotiations between groups themselves.

V. CONCLUSIONS

This main novelty of this paper is the integration of cooperative and project based learning in an open platform like OpenMoko. The course has been designed to consider both learning methodologies and to take advantages of their benefits. The obtained feedback signals the integration stage and the link with real life as the most interesting issues covered by this course.

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