Ubiquitous Computing and Collaboration

New interaction paradigms in the classroom for the 21st Century

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Abstract: In this paper we are presenting the foundations and groundworks of the activities performed by the CHICO team at UCLM in order to study the methods and techniques to design the so-called Classroom for the XXI Century. Our assumption is to establish the conditions to develop the classroom in which the principles of ubiquitous computing and collaboration will meet together to accomplish and help CAI objectives.

1. INTRODUCTION

The worldwide use of computers in all the fields of human activity, together with the decrease of their price and the increase of their power and versatility has made them grow to tremendous popularity over the last several years. We cannot claim so about their use in the education domain, where the introduction of computers, still being gradual, does not reach the usage range and acceptance necessary to make the qualitative jump they can.
The simple fact of placing a computer in the classroom does not guarantee its use. However, there are some data [1] that confirm that everyday lessons (in Higher Education in the USA) have been undergoing the most significant change in many decades, a change directly influenced by the use of computers in the classroom. The members of the CHICO team (Computer Human Interaction and Collaboration) are conducting an ambitious project centred on the experimentation and research of new interactive technologies susceptible to be applied in the classroom. Thus, we try to change the traditional concept of a lesson or class. In particular, studies and developments are being carried out to turn the classroom into a ubiquitous computing environment where computer-assisted collaboration help students to solve complex problems.

To a certain extent, the personal computer has been introduced in the classroom, but its use is not coming up to initial expectations, as, indeed, it initially happened with audiovisual aids and other similar tools. The provision of computers in school labs, the attempts to develop a large amount of computer material and software for the subjects to study, the training in their use and the initial motivation are not bringing about their generalised use. It seems as if there were primary, basic elements in the educational activity in the classroom hindering the progress, impeding the immediate change to another tool that can theoretically accomplish the same or better results. There are social habits necessary to evolve but impossible to replace immediately. We are making reference, for example, to the use of such elements as the blackboard, the paper and the pencil. Ubiquitous computing will allow their evolution, without replacing them. In this article we present the groundworks and the architecture of the first implementations undertaken. In section 2 we introduce the concept of ubiquitous interaction and the hardware necessary to make it possible, according to Mark Weiser’s view [2], applying the current technical developments and our view of ubiquitous computing. In section 3 some principles are described on which lay our ideas of collaborative environments. Section 4 describes the model established for the first implementations. In particular, a language learning activity case as an instance for a ubiquitous class, carried out as a real experiment. Finally, section 5 determines some conclusions that have already been reached and the directions to guide our work in the future.

2. UBIQUITOUS COMPUTING

Ubiquitous computing as the interaction paradigm was first introduced by Mark Weiser in Xerox PARC laboratories in Palo Alto in 1991 [2]. This new
paradigm changes the concept of using the computer by distributing multiple low-powered computers or small computer components throughout the environment, trying to hide their presence, concealing their use [3] by disguising their appearance adapting them to the traditional tools used in the classroom. In other words, ubiquitous computing tries to extend the computational capacity to the whole environment by means of the distribution of small and very diverse devices with specific interactive characteristics, connected to higher powered servers. The design and location of these devices must be thoroughly analyzed according to the task they are to perform. This way, the computational responsibility is dispersed, loosely distributed in the environment, giving an impression of omnipresence [4].

In his already well known article [2] and in some later works [5], Weiser describes with detail his revolutionary views: how computer ubiquitousness can help us in our lives, without being intrusive to us. The solution proposed by this author consists in having wireless networks of computers interchange information between themselves and serve as interaction mechanisms. In ubiquitous environments there are three types of computer devices: “badges”, “tabs” and “whiteboards”.

The badges are small machines, a few centimeters wide and long, similar to labels but unlike these they are active. They have a small microprocessor and infrared technology to broadcast the identity and the location of the person holding them. These data can make doors open just by approaching them, or similarly, adapt some information displayed on a screen to the badge holder. The tabs, as large as a LCD screen, are used in the same way as we use the paper, a book or a magazine. They have a radio frequency connection with enough channels to connect with hundreds of such devices, enabling communication to every person in a different room. The objective of these tabs is not for the users to permanently carry them but to use them where they are with no type of associated identity, a characteristic radically different from portable computers. Finally, the whiteboards have the habitual size of those in a classroom and serve as any device used to show information, i.e., as a video monitor, a notice board, a display panel, or even as a screen shared to download information coming from the badges and tabs or to upload data to these. In order to use them a marker, a piece of “wireless electronic chalk”, is used.

These computers were designed at Xerox Research Center in Palo Alto [5], and in a later article [6] Weiser affirms that it is at the university where his idea of ubiquitous computing can have more acceptance. In 1999 Ortega [7] reckoned on the implementation of this new paradigm in the classroom with educational aims, presenting some of the benefits that its use will provide in education. Soloway [8] considers that handheld type or PDA
devices mean a new incentive in the way to exploit the power of learning by
discovery. Following the principles of the ubiquitous computing paradigm,
He conceives these devices as remote controls of a group whiteboard. He
proposes to design peripheral devices and use these, say, handheld devices,
for data capturing in a real environment. Later these data will be sent to a
server which will display them for group discussion. The dream of the
ubiquitous computer is on the verge of becoming real with these tools.
Devices with high calculation capacities and capable of interconnection
without cables are a reality. As some authors [8] suggest, if we add the
possibility of handheld devices interconnected by means of wireless
networks we practically have the system described by Weiser in 1991.

3. COLLABORATIVE SYSTEMS WITH
UBIQUITOUS COMPUTING SUPPORT

From the learning perspective it is necessary to emphasize the theory of
collaborative learning as the central source of support in our expositions. In
the search of a theoretical framework to use as reference we are to
emphasize the CSCL paradigm (Computer Supported Collaborative
Learning) [10]. This paradigm is mainly based on social constructivist
theories [12], the theories on situated and shared cognition [12.13.14] and
mainly on the Soviet historical-cultural theory arisen from the works by
Vygotsky [9]. According to this author “According to this author "In a
collaborative scenario, the students exchange their ideas to coordinate in the
attainment of shared objectives. When dilemmas arise at work, the
combination of their activity with communication is what leads to learning”.
Many systems have been developed on the basis of the principles of the
CSCL paradigm, to mention some: the CoVis project (Collaborative
Visualisation) and its “Collaborative Notebook” [15], CSILE [16], CaMILE
[17], KIE [18], C-CHENE [19], SCOPE [20 ], etc. In the Spanish university
we can point out the developments contributed by a group at UNED in DE-
GREE [21], and even, in all modesty, the CHICO team firmly reckon on
these principles in DomoSim-TPC [22,23,24 ].

However, when we try to fuse the principles of the CSCL and those of
ubiquitous computing we must consider certain aspects. In this sense we
dare to establish a classification of systems according to the characteristics
of ubiquity involved and to the kind of collaboration adopted:
– Systems that only support file downloading and uploading.
This type of systems implement mechanisms for downloading file from a
server to mobile devices in order to get them work off-line later. Then the
resulting work can be transferred to the server for storage. In order to approach the design of such a system we only need a PDA or a handheld device and some software tools based on file management, email or hypertextual interfaces.

- Systems that support collaboration in asynchronous discussion interfaces.
  The aforementioned systems lack group work facilities. In order to progress over this obstacle there is another type of systems which, in addition to the information management functionality, provide a set of tools for discussion making it possible to present individual work to the group. These systems define both an individual workspace and a group workspace for discussion, even in some cases areas of results, but only of an asynchronous type.
- Systems that support synchronous collaboration.
  The asynchronous discussion facility provides innumerable benefits from the social point of view. However, in a great number of situations and domains it becomes essential to have tools for interaction and communication in real time. The systems that support participation and discussion in real time are more complete but also more complex. In these, in addition to the definition of workspaces it is necessary to define work sessions and protocols [25] in order to structure and lead the interaction of the participants with the system. We can mention some of the works of Soloway and its collaborators [26] as examples of this type of systems, still susceptible of improvement (mainly as to collaboration). The CHICO team commit their research work to systems supporting collaboration in real time and rely on ubiquitous computing as the new interaction paradigm to design the model that Ortega [7] claimed to be the classroom of the future, already feasible at present.

4. A MODEL OF AN ELECTRONIC CLASSROOM FOR LANGUAGE LEARNING

Our objective works on the definition of a classroom model based on the principles of ubiquitous computing and computer-assisted collaborative learning as a low cost system, to apply it to language teaching as a case study. Thus, we are going to describe the architecture proposed below (Figure 1). Then, we are going into the most important details about the application of this case study.
4.1 Architecture to support ubiquitous computing and collaboration in the classroom.

The architecture is based on the use of several wireless network technologies. We have used some commercial devices and others develop in our laboratory. It includes the following elements:

![Model to implement ubiquitous computing and collaboration](image)

**Figure 1.** Model to implement ubiquitous computing and collaboration.

4.1.1 Wireless network

As wireless network we used a commercial product, ELSA AirLancer, a set of wireless connections instead of the standard wiring of a local area network (LAN). This brings about wireless local area networks (WLAN) that have the same functionality as a LAN. They improve these facilitating the integration of mobile devices. Wireless network cards use the IEEE 802.11b standard, a modification of IEEE 802.3 for Ethernet connections. IEEE 802.11b standard uses a range of ISM-type frequencies (Industrial, Scientific, Medical) from 2.4 to 2.483 GHz, with a bandwidth of 11 Mbps. They can reach a range up to 300 meters outdoors and around 30 meters inside buildings, with an average speed of 5.5 Mbps transference, which provides an excellent solution for the classroom environment.
4.1.2 Infrared emission and reception.

The transference of information by infrared emission is achieved by using devices with the IrDA standard (Infrared Data Association) [27], which was specially designed for communicating palmtop devices, laptops and mobile telephony terminals. At the present time there are a lot of peripherals with this type of communication ports for wireless connection and communication. Even when there are no such connections we can expand the tool by means of IrDA devices that directly connect to the RS232 serial port.

4.1.3 Ultrasounds devices.

In our model we also use ultrasound technology to determine the position of the mobile devices. They have an ultrasound emitting device to be located. They work the same way as Weiser’s active badges. Commercial devices of this type exist, even at very low cost, used for tasks as simple as length measuring. However, we made use of previous works already developed in our university for mobile robotics [28]. They provide measures with a 2cm margin for error.

4.1.4 The Whiteboard Projection Set

For whiteboard projection we use a whiteboard and an overhead projector (OHP) connected to the VGA card of the computer used as the session coordinator. This way, when required, it is possible to have the information projected on the whiteboard.

4.1.5 The Editing Whiteboard

In addition to the Whiteboard Projection Set (or as an extra tool attached to the WhiteBoard) we use a device capable of capturing what is drawn or written with a marker (or electronic chalk) on the Whiteboard. Once caught, this information can be processed and be sent to all the mobile devices through the wireless network. This way everybody can share the information in real time. There are some research works in this line such as the ones described in [29] and the ones based on artificial vision [30]. Nevertheless, we have decided on a low cost commercial device called mimio™ of Virtual Ink™. It is an easy to use, portable hardware tool. It stores, reproduces and prints the information drawn on a whiteboard. It incorporates a bar-like sensor attached to one of the whiteboard sides. It is connected to a series of sensors to be placed in markers and to another device, the eraser, to clean or
erase the whiteboard. The Editing Whiteboard constitutes itself a powerful tool to make presentations and even to share information through an Intranet or the Internet. The connection of the mimio™ to the session coordinating computer is made by means of a RS232 serial port, but, as seen above, everything seems to indicate that we can do it by means of an IrDA connection. Tests are being developed in this sense to reach this objective.

4.1.6 Session Coordinator

The Session Coordinator is a computer with communication interfaces to connect all the described technologies previously referred. Therefore, it is the one in charge of receiving, processing, storing and distributing all the information flow. To this purpose, another computer is in charge of the data management, doing the functions of an information server, implemented in a database management system (in our first experiences we are using MySQL accessed trough JDBC).

4.1.7 Mobile devices

The mobile devices, as Figure 2 shows, are formed by a set of PDA (Cassiopea of Casio or iPAQ of Compaq) using a PCMCIA card or MMCard extended module for integrating the hardware necessary to have access to the wireless network to enable information interchange. Additionally, they have an ultrasound transmitter/receptor device integrated so that this way the device holder’s location can be tracked in the environment. Thus, the Session Coordinator can determine that a person with a mobile device is approaching the whiteboards and can, for example, directly project the information contained in their PDA on the Whiteboard Projector, reproducing the messages they bear, to mention one of its utilities.

Figure 2. Mobile device.
4.2 The model applied to Language Learning.

In order to implement this model we are presenting a traditional activity, the writing of a composition in class, in the domain of language learning, in particular, English as a Foreign Language (EFL). This case study already poses an innovation itself: to practise the writing of English in a collaborative environment where a group of students work together. At the same time, all the process is guided by the computer that will as well participate in the composition development by means of the ubiquitous computing paradigm.

Generally, in the teaching of English, composition writing is an activity where the students have to write on their own. They are given, at most, some instructions on the type of composition to make, whether they have to write a description, an explanation, a narration, a letter, a report or the expression of their views, and the title or topic. Usually, the writing of a composition is either a homework task, with access to all type of aids available, or else a testing technique. In both cases it is an individual activity.

In our class we propose this task with the habitual instructions, but the students must work in group and at any moment they can get help from the computer, from the other members in the group and be guided by the teacher.

In writing a composition, as a well structured activity for language learning, the student is usually advised to put down a schema with the main aspects to write about. Brainstorming follows in order to develop the aspects. This is achieved by means of note making and it is an eminently conceptual or lexical process, made up of phrases mainly. Once those ideas have been organised and selected according to the relevance of their contribution to the development of the aspects, the students begin to extend them into correct sentences and coherent paragraphs. This is the syntactic part, the one of formation of the grammatically correct sentences and of the textual organisation of these into connected paragraphs.

This way, in a ubiquitous collaborative environment, the teacher tells the students the topic and the type of text to write. The students begin the activity with the process of brainstorming, suggesting aspects and ideas to the group by means of their mobile devices. They use them to send and to receive all the set of suggestions (collaborative brainstorming), which will be shown on the Whiteboard as well. For this purpose, we have developed an easy to use interface by means of a document in dynamic hypertext language DHTML. It consists of an interactive form where text boxes are available in order to insert the annotations and buttons are provided for their submission and reception. These activate the communication through the server (Figure 3).
The students can receive the content proposals of the group and thus decide on which they consider most appropriate and excellent for the composition. At the same time, they can add, if they wish, other derived ideas or extend either the suggested ones with more precise or complex annotations. At this point the first grammar elements soon begin to appear to cohere the notes (content words and phrases) into whole ideas (more extensive phrases and sentences). Next, the discussion process is carried out to select the most significant contributions and to organise them in the most appropriate order. In this process it is important to point out the role of the teacher as a guiding expert, controlling the level of knowledge and the adequacy of language use, suggesting an optimal plan with the proposed elements, etc. This can be carried out orally or with written messages enabled by means of a chat interface.

When the group reach an agreement on the selection and organisation of the notes, the process of text formation begins. Here appears the role of the computer as an aid. Depending on the level of language knowledge the group should have, the lexical choice can vary from very basic words, with frequent repetitions, to less frequent, richer or newer vocabulary which they can come to use without being sure they are correct. Our system facilitates access to dictionaries of all types: monolingual, for common definitions and
word combinations ("collocations"), as well as bilingual, to translate new concepts, and thesauruses, to avoid repetition and to learn new vocabulary. They can also revise the resulting text by contrasting special expressions in a lexical database arranged for this purpose in the system. The lexical database is composed of a variety of original texts and a case library, i.e., the compositions previously made corrected by the teacher. We are implementing a programme for syntactic analysis to use as grammar corrector and style checker, but the student can already count on a grammar reference tool which gives help depending on the type of composition to write.

The teacher’s role involves not only the correction of mistakes but also guidance as an expert as previously referred, and, after the first part of the activity, as an organiser in the distribution of tasks, making some students revise for grammar mistakes, others for vocabulary choice, and others for connectors, textual organisation and style of the composition. Once finished, the text is proposed for the group’s general approval and for formal hand-in to the teacher, who evaluates it and includes it in the library of cases.

5. CONCLUDING REMARKS

We reckon on the architecture described as a first experience to take Mark Weiser’s ideas to the classroom environment with practical technology. Therefore, we are taking these ideas from conception into life, from prediction into reality. The model supposes a challenge as well as an attractive framework to research. We try to extract the implications of ubiquitous computing in computational systems for group learning in particular and group work in general. The ubiquitous computing paradigm has made it possible to adapt the activity of doing exercises in class as a collaborative task. At first sight it is not necessary to carry out extraordinary changes in the class management. The students still take notes and write in something similar to a small notebook, they frequently direct their attention to the whiteboard, where the teacher displays certain information. There is no need to change position in the classroom and the individual participation remains. But in all this activity underlies the contribution of a series of electronic devices that make this technique possible: collaborative work based on ubiquitous computing.

This learning methodology makes advantageous use of the continuous communication in group and the teacher’s individualised attention to each student. Furthermore, at any moment there are access facilities to aids and guidance, in our case study by means of dictionaries, grammar guides and texts available in the system. All this entails a faster assimilation of the
group work technique where each student’s individual contribution remains effective (and traceable) in the final result. The teacher is still present like in the traditional classroom and, what is more, their participation giving instructions to the whole class as well as commenting and guiding each student’s individual proposals can be followed by all the group through the electronic whiteboard. The students will also follow the teacher’s making changes in the organisation and assigning tasks throughout the process. They can even follow the process of the teacher’s corrections and final revision, if this is considered advisable.

There is still much to do. The application of our model to other domains and study cases will entail certain modifications in the traditional concepts of teaching, as well as in the most recent theories of learning we had tried to implement (without much success) considering the computer as a desktop tool. In this case, we go beyond teaching focused on the individual results and beyond the direct manipulation of the learning tool.

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