A Tablet PC-Based Teaching Approach using Conceptual Maps

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Abstract— **There are clear evidences that technology can drive major positive changes in the classroom addressing problems associated with traditional lecture-based pedagogy. In particular, the flexibility of Tablet PCs and digital ink has the potential to achieve a wide range of educational goals and promote a more dynamic classroom environment. However, as the possibilities of these educational technologies grow, it seems necessary to consider their role by conceptualizing the knowledge they provide. In this work we propose a teaching approach based on the use of conceptual maps to generate instructor guidelines for Tablet PC-based courses. Our approach combines the instructional domain with the technological one in order to offer practical guidelines to design and develop both lecture materials and active learning experiences, providing a systematic and flexible way to guide the teaching process in a Tablet PC-based learning scenarios. We present a case study on how to implement the approach in a first-year Computer Engineering course reporting the introduction of the Tablet PC in this educational setting.**

Keywords- Tablet PC; Digital Ink; Conceptual Maps; Instructional Design.

I. INTRODUCTION

The widespread adoption of slides displayed with a digital data projector has supposed an unquestionable technological change in the classroom. However, it has no essentially modified the lecture model of instruction, which is still prevalent in many of our Computer Engineering (CE) undergraduate courses. It is often difficult to maintain concentration of students for the entire 2-hour lecture sessions, especially when there is a lack of variety in the teaching method. Stuart and Rutherford [1] assessed students' concentration during a didactic lecture and found that ''concentration rose to maximum at 10-15 min. and then fell steadily until the end of the lecture''.

One of the latest trends in instructional technology is the use of Tablet PCs in the classroom. In recent years, Tablet PCs are making its headway into classroom instruction at every level, from primary and secondary school, to higher education. In fact some recognized institutions, such as Virginia Tech, have adopted, since 2006, a mandatory program requiring all first-year students in College of Eng. to own a Tablet PC [2].

Recent research demonstrates obvious advantages of using Tablet PCs in higher education. In fact, there are clear evidences that technology can drive major positive changes in the classroom, addressing problems associated with traditional lecture-based pedagogy [3].

However, we think that any random implementation of educational technology has a low probability of success and widespread adoption. We consider that clear guidelines are required to develop and deploy such new technology settings. As the number and possibilities of Tablet PC and pen-based technology grow, it seems necessary to consider the role of these educational technologies by conceptualizing the knowledge they provide. There are different tools to represent and organize these knowledge items and we have selected conceptual maps [4] as one of the more flexible and powerful techniques to support this process. Concept maps are graphical tools for organizing and representing knowledge. They include concepts and relationships and their use permits modeling mental trees of assimilated concepts to a simple format.

In this work we propose TAGGE (*Teacher Assistance Guideline Generation Engine*), as a teaching approach to generate instructor guidelines for preparing interactive face-to-face courses supported by technology. Based on the learning requirements of a specific educational setting, TAGGE uses conceptual maps to model the instructional domain and the technology domain in order to provide clear teaching guidelines, i.e., the outputs of our approach. These guidelines will then be used by instructors to adapt traditional courses to an active learning technology-based course. The main idea behind TAGGE is, on the one hand, the conceptualization of the instructional and technological domains using conceptual maps and, on the other hand, to relate the instructional domain to the technological issues in order to propose the teaching guidelines.

This paper is organized as follows. Section II reviews the related works using Tablet PCs and conceptual maps to enhance the learning process. Section III presents TAGGE, our teaching approach. Section IV describes the conceptualization of an educational setting example. Section V presents the teaching guidelines offered by the TAGGE approach in this particular context. Section VI describes the teaching context of our case study and presents some preliminary results. Finally, Section VII presents some concluding remarks.

II. RELATED WORK

In this section we first present some of the most outstanding works using Tablet PC to enhance learning and to promote student engagement. After that we review some of the fields where conceptual maps have been applied.

A. *Using Tablet PCs on Education*

The advantages of using Tablet PCs in a classroom have been reported by several studies in the last few years. In [5] authors used the Tablet PC in an upper level Electrical Engineering course for both content development and presentation. Tablet PC was also used in [6] for several undergraduate engineering courses, which clearly showed how it facilitates collaborative and active learning, allowing the instructor to spend more time on explaining concepts rather than drawing figures. In [7] classroom instruction using a Tablet PC with standard PowerPoint presentation and whiteboard are compared. The authors reported that Tablet PC-based class presentation showed better attention rate and better comprehension of the material. Tablet PCs are also being increasingly used in secondary school where the overall learning process is greatly improved if they use Tablet PCs [8].

In terms of instructional tools, *Classroom Presenter* [9], developed by the Univ. of Washington, has the ability to enhance the usage of PowerPoint-based slides, allowing students to communicate among themselves and the instructor in real time. *DyKnow* software [10], which has two interoperable programs within it, *Monitor* and *Vision*, is another interesting example. *Monitor* enables the instructor to monitor and/or block unauthorized student computer activities, while *Vision*, fosters interaction through collaborative note taking, student response tools, content replay, and anywhere, anytime access. *WriteOn* [11] is another tool, which can be used together with Tablet PCs to allow annotating on top of any application visible on the Tablet screen.

B. *Applying conceptual maps*

II. Concept maps have been around for quite some time, and their principles are deeply rooted on well-known learning theories. Their adoption sought to offer an Ausubelian perspective of the knowledge acquired [12] by allowing to externalize mental trees of assimilated concepts to a simple format. In terms of learning approaches, concept maps offer the evaluator great insight and help at detecting misunderstandings and flaws in the learning process strategy. Concept maps were first proposed by Novak [4] a few decades ago. They consist of a very flexible structure that allows users to create meaningful relationships between key concepts so as to improve the processes of learning and knowledge acquisition in general. Since their invention, they have received much attention from researchers and experts worldwide. In fact, concept maps have been used in various areas of knowledge with heterogeneous purposes such as creating cross-language tools [13], thereby simplifying concept translation between different languages, as a tool to enhance web searches [14], in the evaluation process in Computer Engineering Undergraduate Courses using objective metrics[15], or even to improve the public outreach of the Mars exploration mission[16].

In this work we used concept maps in order to model the instructional learning domain and the Tablet-PC technological domain, and thus generating teaching guidelines in Tablet PC-based courses.

III. TAGGE: OUR TEACHING APPROACH

This section introduces TAGGE, our approach to generate teaching guidelines for technology-supported courses. This approach is based on modeling the knowledge items about instructional and technology issues that are part of a specific course. This conceptualizing process will enable the guideline generation in a more systematic and flexible way.

Fig. 1 shows the conceptual framework of TAGGE. It takes the learning requirements attached to a specific course as inputs (e.g., the learning general needs, the learner profile, or the course subject features) and processes them to obtain the guidelines to assist instructors in a particular learning scenario. The basic under TAGGE is the conceptualization of the instructional and technological issues for a given learning scenario (e.g. a course). There are different tools to represent and organize these knowledge items and, in this case, conceptual maps have been selected as one of the more flexible and powerful techniques to support this process. Concept maps are graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes, and relationships between concepts, indicated by a connecting line linking two concepts.

Starting from the conceptual maps representing the instructional domain and the technological one, the processing performed by TAGGE is organized in two steps. First, the learning requirements are fed as inputs to the TAGGE environment. These variables are used to modulate instructional issues such as learning objectives (e.g. getting theoretical knowledge or promoting hands-on skills), course resources (e.g. lecture handouts or lesson scripts), learning tasks (e.g. assignment, project elaboration or portfolio development), or assessment activities (e.g. summative vs. formative strategies). Once the basic instructional concepts have been selected, their relationships with other descendant concepts are searched. The second step starts when concepts located at the technological map are "detected" using relationships coming from instructional "leaf" concepts. These technological-based concepts should be instances of higher class concepts in the map (e.g. Desktop Sharing in a Tablet PC context) which define the category concepts used to generate the teaching guideline. Attached to each selected technological category, several guidelines can be configured as output of the TAGGE system. These guidelines will then be used by instructors to adapt traditional courses to a new technology-supported educational approach.

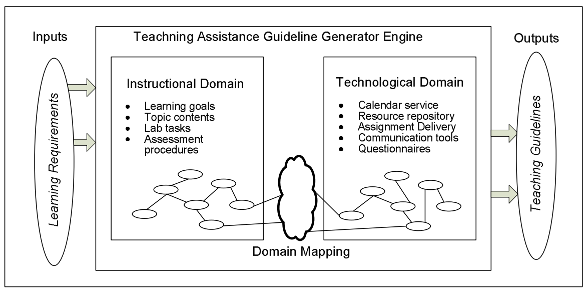

Figure 1. TAGGE. Overview.

Next, we present two conceptual maps which are core elements in our approach. The first one is associated to the instructional domain in a specific educational context, and the second one is related to the Tablet PC domain.

IV. CONCEPTUALIZING THE CONTEXT

In order to illustrate the proposed approach, this section describes a specific context where TAGGE will be applied. On the one hand, Computer Technology, a first-year compulsory course in Computer Engineering has been chosen to describe the instructional domain. On the other hand, Tablet PC devices have been selected as the technological elements in this context. Once both domains have been defined, conceptual maps should be built up in order to organize the corresponding knowledge items.

Fig. 2 shows a conceptual map aiming at describing the instructional model of the course entitled Computer Technology, object of our case study, before integrating the new technologies. Elements located at the top of the map introduce, on the one hand, how sessions are organized and, on the other hand, the assessment strategies. In particular, instruction is organized in face to face lectures, problem-solving classes and laboratory sessions. Instructors take the main role in lectures, whereas both problem-solving and laboratory sessions are focused on the student activity. The lower levels of the map describe the general goals of the different sessions as well as the specific resources that they use. Additionally, this part of the map provides information about what kind of skills students should improve in the different sessions, such as cognitive skills in lectures, communication skills in problem-solving classes or hands-on skills in laboratory sessions. In relation to assessment strategies the map enumerates different approaches that are taken (multiple-choice tests, problems, hands-on activities, student in-class activity). Moreover, it shows some relations with the methodological aspects and how the results may be used.

Fig. 3 depicts a conceptual map that tries to organize the knowledge about Tablet PC technology in a comprehensive manner. In order to better understand the different aspects it covers, we will try to distinguish different areas.

On the top left side of the map, the physical aspects of Tablet PCs are addressed and their main features, such as portability or mobility, are presented. This area also introduces the elements that characterize these devices as a special display screen including a digitizer, and a digital pen, which gives name to a broader family of devices, the pen-based technologies. The three types of Tablet PCs currently available on the market are showed as well: a) slate, b) convertible, and c) hybrid.

On the top right side of the map, different services provided by this technology are displayed, such as presentation delivering, interactive whiteboard, polling, desktop sharing and videoconference. Connected to these services those aspects that may be promoted, are presented as: note taking, collaboration, feedback or communication. This area deals also with specific operating system or software applications related to these devices.

Finally, the map also introduces at the bottom side area the capabilities of digital ink as a key concept in Tablet PCs. In particular, the possibility of using handwritten inputs allows users not only to write in a more natural and free way, but also to mark, to sketch or to draw, among others. In this section, the ability to use a pen to directly write on the surface of a computer screen is also related to the activities that may be fostered, such as: brain storming, prototyping, designing, reviewing, annotating, etc.

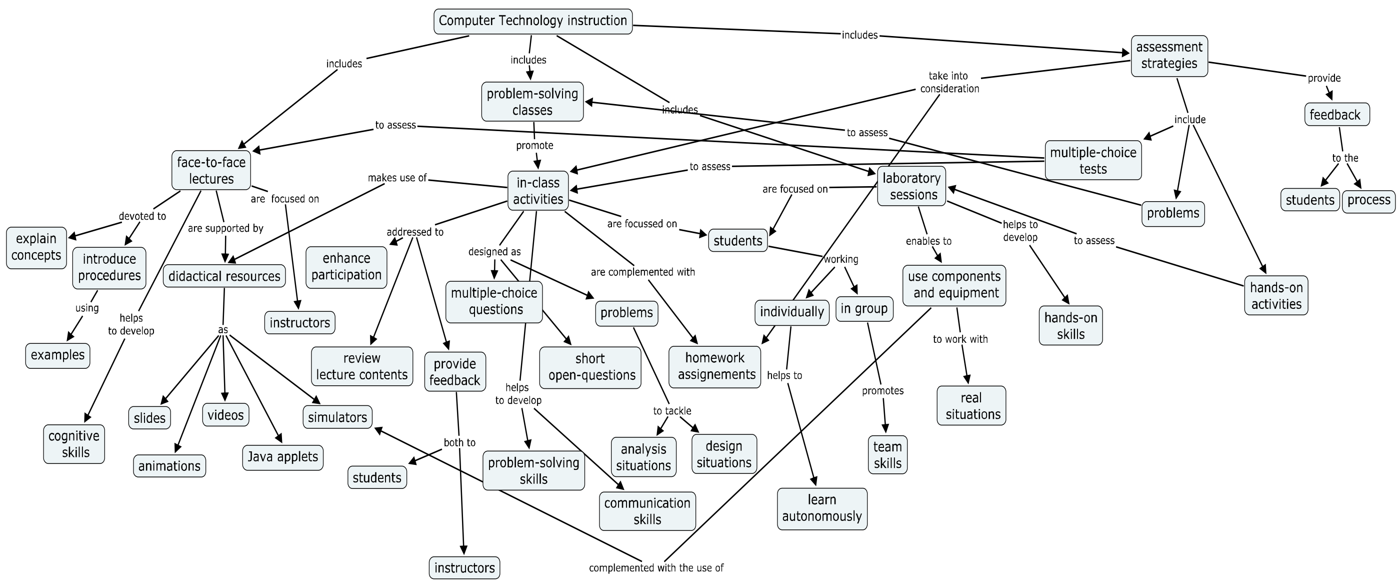

Figure 2. Conceptual map of the instructional domain: Computer Technology course.

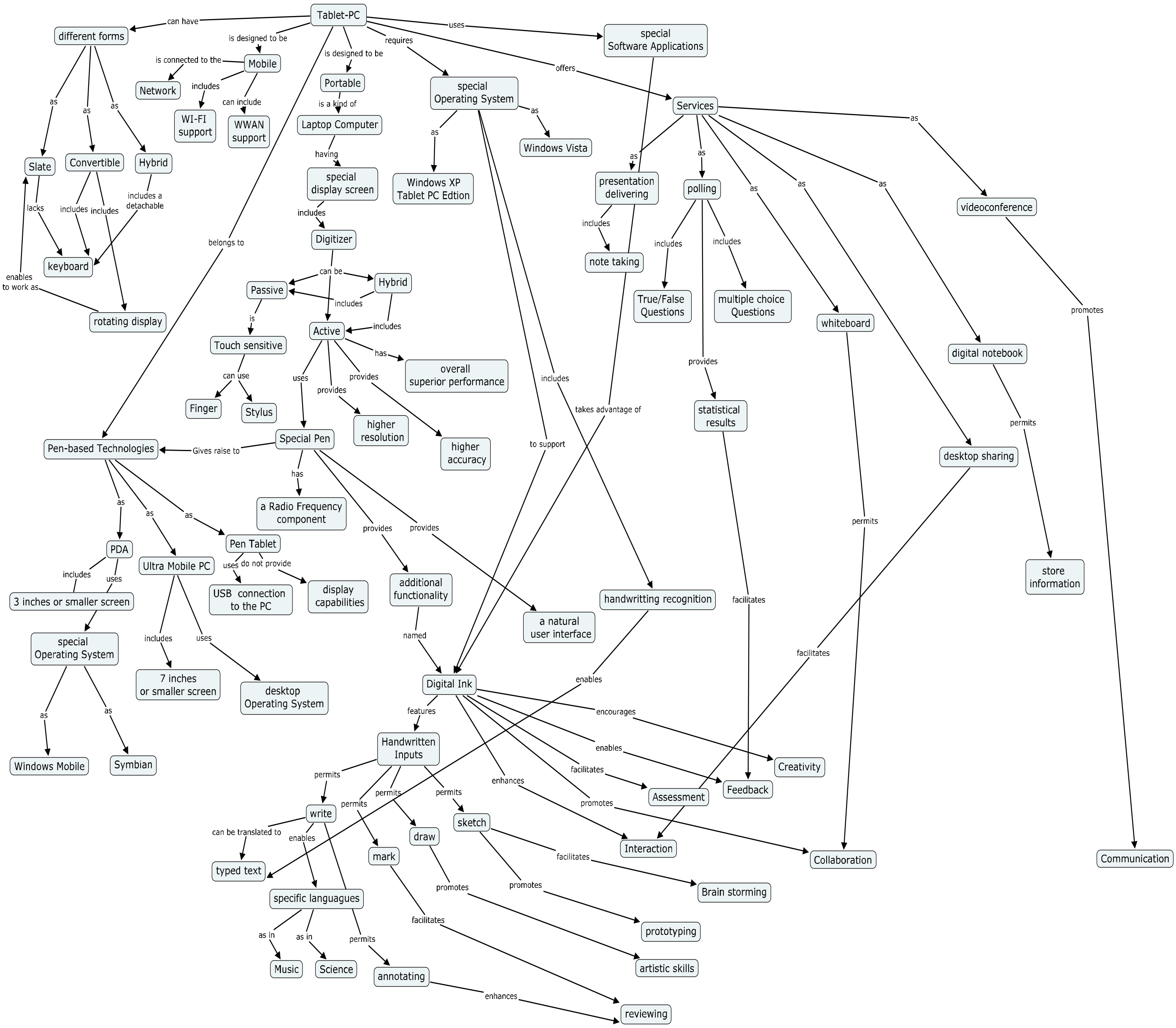

Figure 3. Conceptual map of the technological domain: Tablet PC

V. OBTAINING THE TEACHING GUIDELINES

This section describes the application of the proposed teaching approach to the context example presented in the previous section As stated in the TAGGE description, learning requirements represent the inputs that help to describe the specific context. Concerning the Computer Technology course, over the last five academic years have been observed the following problems: a) pupils' lack of motivation; b) low class attendance rates; c) high course dropout rates; d) low participation and student interaction, and eventually, e) poor students' performance. These issues are also common in other first-year courses. Furthermore, the discipline demands abstract reasoning to understand how semiconductor devices and logic circuits work, problem-solving skills to tackle analysis and design situations, usage of computer simulation tools to help modeling those devices and circuits and additionally, a good knowledge in Physics (more in particular, in topics related to circuit theory).

Once the learning requirements have been set up, the first step of our approach consists in feeding them to our instructional domain in order to decide which are the basic instructional concepts we should focus on. In our particular case, we determine that initially, we should face those instructional factors related to the learner profile, such as engagement, interaction, participation, or feedback; then, we should address the issues related to the discipline itself, trying to obtain a more realistic and motivating approach, by using multimedia resources, computer tools, additional examples, etc. When we try to match these basic concepts to our instructional conceptual map, we find that: a) in-class activities should be emphasized as a way to create more interactive and cooperative sessions; b) those didactical resources that promote student participation should be strengthened, as they could improve both face-to-face lectures and promote autonomous learning; c) assessment strategies should be shaped in order to track learning attainment in a continuous way and also to provide feedback to students and to the process.

The second step of our learning approach connects those basic concepts coming from the instructional domain to the corresponding ones in the particular technological domain. In relation to the Tablet PC domain, it leads us to exploit the inking functionalities and to select which services fit better our instructional issues. In our particular case, we observe that: a) delivering services can contribute to foster student participation and cooperative learning; b) desktop sharing services can help to take the best use of multimedia resources or computer tools and, at the same time, also facilitate the student active role; c) polling services can assist both students and teachers to obtain timely feedback about student attainment and what is better, to facilitate mechanisms to adapt the teaching strategies to the learner's needs.

Finally, teaching guidelines represent the outputs of the process and describe how the technological domain could contribute to fulfill the addressed learning requirements. Table I summarizes the outputs in our case.

TABLE I. TEACHING GUIDELINES

Tablet PC issues	Instructional issues	Learning issues
Presentation delivering services, included in tools as *Classroom Presenter* or *Dyknow*, make use of digital ink functionalities, could be used to:	Increase the instructor's flexibility while lecturing. Facilitate student note-taking. Enable submission of student in-class activity to the instructor and further discussion. Permit archiving of both instructor presentation and student submissions.	Student participation Cooperative learning Enhanced communication with other classmates and instructors Timely feedback to students and instructor.
Desktop Sharing service, as provided by *Yugma*, could be used to:	Engage students in computer simulations introduced as in-class activities. Enable students to assume the presenter role in face-to-face lectures.	Realistic approach of the subject Simulation tools, as PSpice Student engagement
Polling services, also included in tools as *Classroom Presenter* or *Dyknow*, could be used to:	Promote student attainment. Gain knowledge about students understanding related to key course concepts given in lectures. Review misunderstandings and propose reinforcements.	Student self-esteem and confidence Timely feedback to student and instructor
Digital notebook services, as offered by *Microsoft Office OneNote*, could be used to:	Collect all the activities done through the academic year. Review student tasks and provide students with comments and learning recommendations.	Student engagement Student activity tracking Continuous assessment

VI. CASE STUDY & RESULTS

This section reports how the former approach was applied during the spring 2009 semester to Computer Technology (5554), a core course in our Computer Engineering Bachelor, at the Universidad Politécnica de Valencia. The course has 7.5 credits (75 teaching hours), distributed in lectures, problem-solving classes and laboratory sessions. 10 faculty members are involved in the course that the last academic year had an enrolment of 300. Students used to be distributed in 5 lecture groups, 10 problem-solving groups and 15 lab groups.

At present, the course includes two hours of lecture and two hours of problem-solving session per week. In both cases, instructors have a prevalent role whether exposing the contents, supported by a slide presentation, or solving the problems on the blackboard. Several attempts have been made to increase in-class student participation during the last academic years. However, many students are reluctant to present their solutions on the blackboard and what is worst, some declared to drop the course due to the participation demands. As a consequence, these attempts have not significantly improved the overall scores.

In order to apply the approach in this new technology setting, an additional group of just 20 students has been defined. Although this figure could seem very low, it often represents the actual number of students regularly attending to problem-solving sessions.

To measure the effectiveness of the approach, two sections have been compared, the experimental group (20 students) using the Tablet PCs following a 1-to-1 computing approach, and a control group (34 students), following the traditional teaching methods. During all the term we have mainly used *Classroom Presenter*, a Tablet PC-based classroom interaction system that supports the sharing of digital ink on slides between instructors and students to increase the instructor's flexibility while lecturing.

We have used final scores as the main performance indicator, since they were a direct summation of the evaluation of the different activities included in the semester. A 30% passed the course in June in the treatment group while only an 18% in the control group. Other remarkable evidence is that the percentage of students taking the final exam in the experimental group was a 70% while in the control group was only a 29%. Class attendance has also considerably increased: a 60% attended at least 67% of the classes in the experimental group while only a 32% in the control group. Moreover, drop-out rates in the experimental group decreased below 25% while reached almost a 60% in the control group.

VII. CONCLUSIONS

In this work we present a teaching approach that enables the generation of guidelines for technology-supported courses. The proposed approach is based on the conceptualization of instructional and technological issues using concept maps to represent the knowledge provided by educational technologies such as Tablet PC and digital ink. The proposed approach provides teaching guidelines addressed to design and develop both lecture materials and active learning experiences, in a systematic and flexible way. The obtained guidelines have been tested in a case study conducted in Computer Technology, a first-year Computer Engineering course. The results of the test during the spring 2009 semester have revealed a higher degree of students' engagement and an increment in class attendance. We also consider developing computer tools which enable the automatic processing of conceptual maps in order to facilitate the generation of teaching guidelines.

ACKNOWLEDGMENT

This work has been supported by Hewlett Packard, under 2008 HP Technology for Teaching High Education Grant Program. We also thank the Escuela Técnica Superior de Ingeniería Informática (ETSINF) for its support.

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