

Using Tablet PCs and Pen-Based Technologies to Support Engineering Education

Ignacio Casas¹, Sergio F. Ochoa², and Jaime Puenta³

¹ Department of Computer Science, Pontificia Universidad Catolica de Chile, Chile

² Department of Computer Science, Universidad de Chile, Chile

³ Microsoft Research, Redmond, WA, USA

icasas@ing.puc.cl, sochoa@dcc.uchile.cl, japuenta@microsoft.com

Abstract. Several experiences and results of the Tablet PC adoption have been reported, mainly in American universities. Although the benefits seem to be highly interesting, it is not clear if they are replicable in developing countries. In order to try to understand the impact of Tablet PCs on engineering education in Chile, the authors conducted several experiments at the two traditional Chilean universities. This paper reports the experiences and the obtained results, comparing them with those obtained in American universities.

Keywords: Tablet PCs, Pen-based Technologies, Engineering Education, Mobile Computing.

1 Introduction

Every day more and more persons are adopting Tablet PCs as a way to support educational activities. Several researchers have highlighted the contributions of these mobile computing devices and pen-based technologies as a support of the teaching-learning process [1, 8, 11]. Some of the envisioned benefits are the possibility to do hand-writing annotations keeping the metaphor of a paper notebook, and the capability to share resources, support students mobility and collaboration, and count on a mobile repository of educational material accessible and replicable.

However the advantages recognized by the users depend on the features of the teaching-learning scenario. After four years using Tablet PCs in computer science [9] and science education programs [5], we have seen several differences between the benefits identified by instructors and students from developed countries (such as USA) and from a developing country such as Chile.

This article presents a preliminary study about the impact the use of Tablet PCs and pen-based technologies have on undergraduate computer science programs at the two main universities in Chile. The study covers the perspective of the students and the instructors. It also analyzes the benefits, challenges and limitations perceived by students and instructors, from a social and technological viewpoint. This study was conducted based on the recurrent use of three applications: Classroom Presenter [2], MOCET [9] and an extended version of MS OneNote [10].

Next section presents the related works. Section 3 lists the benefits of using Tablet PCs for both, students and instructors. Section 4 shows the empirical study carried out

by the authors in order to determine the impact that pen-based computing have in engineering education in the two main Chilean universities. Section 5 discusses the obtained results. Finally, section 6 shows the conclusions and the future work.

2 Tablet PCs in High Education

During the last years several researchers have been doing experiments in order to determine the impact of using Tablet PCs in education. Some of them believe that a “Tablet PC has the potential to dramatically alter the educational process. This new technology significantly changes the way students and teachers interact. It adds completely new dimensions to classroom interaction by providing digital ink and drawing tools for writing, sketching, and drawing; and for real-time collaboration” [1].

At the moment we have seen reports of particular experiences where Tablet PCs have become interesting tools in certain scenarios. Now the challenge is to identify in which scenario the Tablet PCs can effectively add value. For example, Anderson et al. show how Tablet PCs can be used to improve the knowledge delivery and facilitate the interaction between students and the instructor during a distributed lecture [2]. Berque et al. report the results of using Tablet PC and DyKnow tools to support collaborative problem solving [3]. Davis et al. and Anderson et al. report experiences of using Tablet PC to take notes during a class [2, 4]. In addition, the authors have shown, in previous works, how these mobile devices can be used to improve the evaluation process in computer science courses [9] and also to support the activities of communities of practice in science education [5]. There are also several articles describing educational experiences on physics, mathematics and agronomy, in which Tablet PCs have been used as the supporting platform for the teaching-learning process.

Considering the experiences reported in recent literature, and focusing just on the main features of the Tablet PCs, we can say that the main activities to be supported with these devices are the following ones:

1. **Taking notes.** Students can take notes on the slides the professor shares with them, or just on a digital blank sheet. These digital notes can be organized, shared, searched, emailed and linked to other resources [6]. In that sense, this functionality seems to be highly useful, and better than the paper notebook or even a laptop.
2. **Enrich the lecture presentation.** Instructors can use Tablet PCs to enrich the information they are presenting during a lecture. It could be used, for example, to do marks or make annotations on the slides, or use the Tablet PC as a replacement for (or supplement to) the black/whiteboard [2]. Since digital annotations made on these devices can be shared, the cognitive load of the attendees is reduced.
3. **Support group work.** During work meetings the group members (i.e. students and/or instructors) usually carry out brainstorming, discuss proposals/alternatives to carry out the job, and validate ideas or the work done. Usually a black/whiteboard is used to support these activities; however Tablet PCs could also be used for this purpose [3]. A benefit of using these devices instead of whiteboards is that notes written on the space shared by the attendees are easier to record and share. In addition, it is not longer needed to erase the whiteboard because its physical space is completely used.

In this list we have excluded the activities that can be performed with a laptop. In other words, we included just the activities requiring the special features of a Tablet PC. Please note there are activities that are variants of the listed ones, which were not included in the list. Summarizing, it seems the use of these computing devices could replace the use of the paper notebook and also the black/whiteboard.

3 Impact on the Students and Instructors

Experiences reported in the literature show the students are usually comfortable using Tablet PCs to take notes and perform problem-solving activities [13, 14, 15]. Something similar happens with the instructors' opinion [5, 15]. In addition, most of the researchers that explore the use of these devices in educational scenarios state that Tablet PCs facilitate the active learning [12, 16][Roschelle et al., 2007]. Considering these previous works, some of the main contributions reported about the use of Tablet PCs, are the following ones:

- **Benefits for students.** Students recognize the possibility to take notes is an important contribution of Tablet PCs usage. The free-style handwriting possibility makes the students more comfortable to express their ideas in sketches or annotations [14]. The possibility to exchange digital resources among the students (or with the instructors) was recognized as an important feature [16]. Finally, students find valuable the possibility to store and manage their courses information in digital format [16].
- **Benefits for instructors.** Many instructors have found that Tablet PCs not only can replace the black/whiteboard, but also extend the resources pool to be used during a lecture [6]. It makes the lectures more dynamic and interactive [Roschelle et al., 2007]. In addition, the annotations the instructor performs during a lecture can be easily stored and shared with the students. Several researchers report an increment of the students' interest during the classes and also an improvement in the way used by the instructors to deliver knowledge [13, 16].

Based on the authors' experience, many of the envisioned benefits are inherent to the use of laptops during lectures. Other benefits, for example the change of students' and instructors' attitude during the lectures, could be the result of the redesign of the teaching-learning process performed to take advantage of the Tablet PCs features. Of course, there are several benefits that really are a consequence of these devices usage, for example the possibility to make handwriting annotations on the lecture slides. Next section describes a preliminary study carried out in two traditional Chilean universities, which tries to determine the impact of Tablet PCs in computer science and engineering courses. The study also discusses the obtained results and compares them with the findings reported by other researchers in USA.

4 Empirical Study

In order to try to understand the impact that the use of Tablet PCs could have in engineering education in Chile, the authors conducted an empirical study in two traditional

Chilean universities: Universidad de Chile and Pontificia Universidad Catolica de Chile. This study was performed in computer science courses at the engineering school and it involved several types of Tablet PCs and also software products.

4.1 Experience in the Universidad de Chile

This experience involved students of a computer science course (*CC51A: Software Engineering*) during two semesters: fall 2008 (29 students) and spring 2008 (20 students). Ten Tablet PCs were delivered among the students in order to support two main activities: course examinations using MOCET [9] (Figure 1), and group problem-solving using MS OneNote [10]. In addition, the instructor used Classroom Presenter [2] during half of the course lectures, and students using Tablet PCs took notes during lectures using this software. When the course was finishing, the instructor and the students filled a survey that evaluated the experience of using these devices. Some of the issues identified by the participants were the following:



Fig. 1. Use of MOCET at University of Chile

- **The hardware matters.** Students using particular models of Tablet PCs (DELL Latitude XT and HP Pavilion TX1000) consistently reported problems to write/erase annotations, regardless of the software they were using. In addition, these students also reported precision problems when these devices recognize the stylus location on the screen.
- **The working conditions matters.** Students and the instructor identified the importance of avoiding situations where only some of the students had Tablet PCs. Some educational activities designed to take advantage of the Tablet PC features, for example the group design, were difficult to perform for students that did not have available these devices or a whiteboard. Therefore, if you are going to perform an activity that takes advantage of these devices' features, be sure that all the students count with Tablet PCs.
- **Training is required.** Students and the instructor reported an important improvement in the usefulness of the devices and the effectiveness of their work, once they were trained in the use of Tablet PCs.
- **The instructor mobility becomes reduced.** Because the Tablet PC must be connected to the projector through a physical cable during a lecture, the mobility of the

instructor becomes reduced. After some sessions the instructor started to use Max-iVista [7] as intermediary to recover the mobility. Although the solution was good, it required to have two computers in the classroom to deliver the lecture.

- ***Tablet PCs do not replace the blackboard.*** Although the Tablet PC's functionalities are comparable to those of a whiteboard (and even better in some aspects), the information shown to the attendees through these devices is replaced when the instructor change the slides. In the case of the whiteboard, it acts as an extended screen of the instructor presentation; therefore it keeps visible the information written on it, even when the instructor changes the slides. In other words, students and the instructor think the whiteboard and the Tablet PC are complementary.
- ***Useful to make free-style annotations.*** Students and the instructor highlighted the capability of these devices to make free-style handwriting annotations. Several software products were used to carry out this activity; all of them were useful and comfortable for the users.
- ***They are similar to laptops in several aspects.*** Students and the instructor identified as an important contribution the capability of mobile computing devices to record annotations and manage information in digital format. They also highlighted the capabilities of these devices to share information and communicate among them in a simple way, even when the users are on the move. However, these functionalities are not only available in Tablet PCs, but also in laptops. Something similar occurs with the possibility to perform simulations, or execute or compile programs during the lectures. In other words, several of the advantages reported as result of the Tablet PCs usage are also present when using laptops.
- ***The instructor and the students feel comfortable using Tablet PCs.*** Users felt comfortable using these devices during the experiences. Although some training was required, the learning effort was worthy.
- ***Computing devices could be distracters during lectures.*** Students and the instructor agreed that mobile computing devices can be a distracting element during the lectures. If they do not have a clear role to play during the lecture, their use compete with the instructor's speech.
- ***The redesign of the lecture style makes them more active.*** The participants in these experiences recognized the lectures became more active and participative. However, it seems to be a consequence of the lectures style redesign more than a result of the use of Tablet PCs.

4.2 Experience in Pontificia Universidad Catolica de Chile

This section describes the experiences of introducing Tablet PCs in two courses at the Pontificia Universidad Catolica de Chile during 2007: “*Computing Software Tools for Engineering*” which is a workshop course (*iic2100*) and “*Introduction to Programming*” (*iic1102*). The main objective of the experiment was to motivate engineering students to learn and enjoy the art of problem solving and project team work supported by computers. In order to reach such a goal, we started to use Tablet PCs in the classroom and we modified the dynamic of the teaching-learning process in these courses. Tablet PCs were used in the classroom for modeling, problem solving and programming.



Fig. 2. Use of OneNote at Pontificia Universidad Catolica de Chile

The course *iic2100* was the subject of this experimentation during two terms in 2007. Forty students participated in each semester. Twenty one Tablet PCs (HP Compact TC4200) were delivered among the students. These devices were shared by the students and they were used to support problem solving during lectures (Figure 2). The impact of the Tablet PCs usage was measured based on opinion surveys from students, teaching assistants and professors.

A similar experimentation process was conducted in the course *iic1102: Introduction to Programming*, during the Fall and Spring terms in 2007. One hundred students participated each semester. Twenty one Tablet PCs (HP Compact TC4200) were delivered among the students in order to support group problem solving during lectures.

In spite of all the positive aspects of the use of technologies in the classroom, a few problems were observed; for instance, annoying delays at the beginning of some activities due to instability of the wireless network and software server (a technical assistant was present in the classroom to solve this kind of incidents). Problems also occurred with software tools and their different versions. It was also observed that at the beginning of the class some students had difficulties to turn on the Tablet PC or manage the stylus-pen, due to simple lack of knowledge (this problem was easily solved). Importantly, some students became distracted with the technology and engaged in Internet searching, chatting, playing or e-mailing, but after several sessions this distraction diminished.

The students highlighted, as a positive factor, the possibility to solve problems during classes. They considered the use of Tablet PCs helped to make the lectures more active and interesting. However, they also identified limitations in the problem-solving process because not all of the students counted with one of these devices.

Most of the students agreed that the use of technology motivated them. It is also important to note that in both courses there were no students considering Tablet PCs as an inhibitor factor; however they recognized that some training is required to take advantage of these devices features. They considered that Tablet PCs facilitated the discussions and the group work during lectures.

5 Discussion

At the moment, the use of Tablet PCs in computer science courses seems to have positive effects. However, there is not a comprehensive and scientific study that

shows which are the real benefits of including this kind of technology in our courses. Although using mobile computing devices during lectures brings several benefits, it does not seem to be consequence of using just Tablet PCs. Our experiments have also identified that computing devices can become a distracter factor during lectures, if there is not a clear role assigned to them.

These experiments also have shown that the use of Tablet PCs motivates to students and professors, however it is not clear if the use of laptops generates the same effect. Provided the courses involved in the experiments tried to take advantage of the Tablet PCs features, and following the recommendations of other researchers in the area, we redesigned their teaching-learning process. Now these courses are more active and there is more interactive work during the lectures, which produced a positive impact among the participants. However this result seems to be a consequence of the redesign process more than the inclusion of Tablet PCs.

The experiences help us to identify that not all of the Tablet PCs provide an adequate support for these activities, and the mix of technology and paper-based work is not a good combination; particularly, if students have to use paper notebooks because there are not enough computers for everybody. Although the students recognized the importance of Tablet PCs for taking notes and facilitating group work, the use of these devices requires a training process.

Instructors were happy when using Tablet PCs. They think these devices help to improve the quality of the lectures; however they are not able to replace the black/whiteboard. In one of the experiences, a lack of the instructor mobility was identified because of the use of Tablet PC to deliver the lecture. Such problem was then solved using additional software technology.

6 Conclusions and Future Work

The use of Tablet PCs in engineering education seems to be growing more and more every day. Several researchers have reported experiences of the Tablet PCs adoption, mainly in USA. They have identified a list of benefits derived from the use of these devices.

In order to try to understand the impact of this type of computers on engineering education in Chile, two experiences were conducted at two traditional Chilean universities. The obtained results show some similarity with those obtained in American Universities. However there are others that are a bit different. The lack of resources for every student opens new challenges for the adoption of these technologies in developing countries.

The experiments have also shown that several benefits associated to the Tablet PCs adoption are more a consequence of others activities around this situation. At the moment it is not clear which benefits are the direct consequences of the Tablet PCs adoption, however the balance seems to be positive. More experimentation and scientific work is required to understand its impact of this emerging technology.

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