UNIVERSITY OF SARAJEVO, BOSNIA HERZEGOVINA
FACULTY OF ELECTRICAL ENGINEERING
Sarajevo, September 2010

TEAM END –OF– YEAR UPDATE REPORT ON THE PROJECT

**The application of HP mobile tablet PC technology in the design of
Interactive laboratory experiments in physical and virtual labs**

SEPTEMBER 2010

General Information

- Institution Name : Faculty of Electrical engineering, University of Sarajevo

- City : Sarajevo

- State/Province : Bosnia

- Country : Bosnia Herzegovina

- Project Title : The application of HP mobile tablet PC technology in the design of Interactive laboratory experiments in physical and virtual labs

- Initiative Summary - 3 to 4 sentences that describe your initiative and results to-date

Your initiative website/blog/online space: http://hp.etf.unsa.ba/

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Impact on Instructional practices

The HP tablet PCs and other related equipment that was obtained as the parts with the grant or additionally purchased from the cash part of the grant (HP server PC, Smart interactive board, projector, WAP router, etc) were used to establish totally interactive classroom (named HP Lab) used for lecturing, tutorials and lab exercises initially in three courses that were nominated in the application phase of the HP Technology for teaching grant. Grant was awarded to our faculty in 2008 and delivered in the beginning of 2009 and implemented in spring semester of that year on the following courses:

1. Course in Modeling and simulation that is taught on the second year of the undergraduate study at Automatic control and Electronics Department.

2. Course in CAD/CAM Engineering, taught on the second year of the undergraduate study at Computing and Informatics Department.

3. Course in Numeric Graphics and Animation, taught on the first year of Masters Study at Computing and Informatics Department.

At project implementation phase, although not included in the application phase, starting from the spring semester in 2009, the fourth course was added to the previous three ones, e.g.:

4. Course in System identification, taught on the first year of Master Study at Automatic control and Electronics Department.

HP tablet PCs equipped interactive classroom has enabled the above mentioned courses instructors to substantially improve courses implementation and results achieved in knowledge transfer and courses delivery processes. Some of the most prominent impacts on instructional practices are described in the following text, stating common experience on all four courses, or mentioning specific courses when particular experiences or benefits have been gained.

Better classroom interaction

The use of handwriting on electronic whiteboards allows teacher to make electronic annotations, sketches, notes, comments, etc. over presentation slides with natural handwriting, in real time. This delivers "higher-impact" lecturing style which is more interactive and engaging and captures student's attention and interest for the subject taught, and also encourages their active participation in their learning process.
Furthermore, owing to its light weight and handy form factor and wireless connection, instructor used to walk along the aisle in the interactive classroom, delivering the lecture or instructions with body active motion, while writing over the tablet or underlying the facts displayed over the interactive smart board.
This double level interactivity (at PC tablet level and at image projection board level, see the Figure No. 1) has been keeping students totally absorbed in the subject, leaving them no room to hide in back benches and do their own work, most frequently not related to lecture or tutorial presentation, as it was case with the old ex cathedra way of lecture delivery.

Figure No. 1: Smart interactive board being used in lecture delivery within HP Lab

One more dimension of interactivity and variety and richness in lecture delivery is achieved owing to wireless connectivity of instructor's and students' Tablet PC. With tablets having connection to WLAN and Internet, the instructor is now in possibility to use not only his tablet for presentation and demonstration delivery what is available on his tablet PC, but also, from interactive board, he can connect with a finger touch, to any virtual PC in private cloud created on HP server type ML350, and demonstrate and use the programs running on these virtual machines in cloud to illustrate the ideas and concepts behind the theory.

This was particularly useful for the courses on Modeling and simulation and System identification, since the transfer of knowledge is much more effective and student attention tied to lecturing, when theoretical concepts and derivations can be immediately illustrated with practical "eye opening" examples, running on virtual PCs in cloud.

Mobile teaching

With Tablet's built-in wireless functionality and WLAN connectivity, the instructor is able to get an always-on connection to the Internet and faculty WLAN from anywhere. Because Tablet PCs are lightweight, they are much easier to carry around then any laptop before. This enabled teachers and students to get access to the information quickly and easily at anytime from anywhere across the campus, and encouraged them to do more and more online. This also increased the efficiency in

materials distribution where the teachers were able to share coursework electronically over a wireless connection, as well as to install and use several software collaboration packages like **DyKnow** and **Wimba**.

Good example for this is the case with lectures and lab works in the course on Modeling and simulation, where the students were able to exercise themselves how to monitor and control pilot plant wirelessly and over the Internet connection, while observing themselves the effects of their issued commands, standing in front of the pilot plant, as can be seen from the following picture, depicted as Figure No. 2:

Figure No. 2: HP Tablet PCs utilization in pilot plant monitoring and control

The full video of this mobile interactive training exercise on the pilot plant can be viewed on our HP project web site on the link:

http://hp.etf.unsa.ba/

Grading

Tablet PC technology has also made grading of students' work process mach more efficient and carried in real-time. With its ability to combine digital ink with the familiar features of a word processors and classroom interactive software, it was now possible to grade papers with personal notes in handwriting with digital ink. This made the grading process itself not just evaluative but instructive as well. Now,   in cases when instructor is walking around the classroom to view and assess the work in progress at each student desk, he/she is able to make the comments on students work from his/her tablet (using software packages like **DyKnow, realvnc or Wimba**) which could also be projected on the interactive board in case that there was a need to draw attention and demonstrate it to the whole class.
In the same time instructor could enter with digital ink his/her remarks on student performance and save it in student's folder, or assess the student work entering mark in Excel spreadsheet.

Field visit

The tablet PC features like portability, interactivity and ease of data entry, and long autonomy in operation without power supply have excelled in the course on Numeric graphics and Animation and its curriculum requirements.

The field visit is part of the course assignments during which students visit location of the historic sites where they had the heritage site objects assigned to them. They are required to model and catalogue them, as part of cultural heritage acquisition and presentation project.
Since the Tablet PCs can be used anywhere, including "on field" and "at site" and "in situ" learning environment, their mobility has increased external learning opportunities by enabling students to work with their models directly "on site" (see the next Figure No. 3), comparing digital model of heritage sites they have created using 3D software tools like Maya and 3DS Max to their real-world originals.

With previous desktop or standard laptop PCs in the computer labs, field visits with the computer equipment were not possible. The students have always been working in the field carrying various on spot activities like taking measures, photos and visuals and then bringing them to the lab to continue working with various photo and image modeling tools collected on site to create their models.

Figure No. 3: Students are comparing the 3D model on the
HP Tablet PC with the original object on the site

Storyboarding

Next to the field visit, as the activity that highlights the reward of using Tablet PC is the case of storyboarding, when HP tablet PC and Autodesk Sketchbook Pro software package were used for storyboard creation and animation projects.

Advantage of using HP Tablet PCs in this course project was obvious from the very start, as the project would be very difficult to accomplish using standard desktop and laptop environment.

Before then the HP tablet PCs were available, the students were drawing storyboards using classic technique of pen and paper. Storyboarding with Tablet PCs has gone a significant step further over traditional storyboarding using the paper. Now, utilizing this technology, storyboard has become digital document with multimedia content and experience – it may be accompanied with the sounds, images, text, videos. There is also possibility to sketch in layers which enable designer to explore design iterations with layer after layer just like on translucent paper, but without unnecessary repeating drawing with previous layer's elements. One more advantage over the traditional storyboarding is dynamic symmetric drawing, the technique which has capability of mirroring strokes on a horizontal, vertical or simultaneous horizontal-vertical axis.

Impact on Student learning experience

We have been evaluating the effects of the Tablet PC based lecturing on the students' learning by:

- Interviewing students about their opinion of the use of the technology implemented within interactive classroom   HP Lab,   with respect to teaching and learning

- By comparing overall student performance with the courses in which students did not have the benefit of the Tablet PCs and interactive HP Lab.   We compared students' final grades; passage rate and project scores in those two cases.

Student comments

These observations were gathered by informal talk with students. They were asked about their familiarity with Tablet PCs and other hardware and software installed and implemented in HP Lab, their opinion of the use of the Tablet PC in the courses, and their perception on the overall impact on their learning.

Students generally felt that it was better to learn with Tablet PCs and the other interactive means provided within HP Lab, than to learn without them. For them learning and working with Tablet PCs was more fun and attractive. They felt that they worked faster and that the quality of their work was better when using Tablet PCs and overall learning environment of HP Lab.

They reported that using of the pen was timesaving, since it makes taking the notes faster and documents and information more accessible. They also liked the possibility of annotating and highlighting text electronically. They appreciated having a wireless access to Internet, provided within the HP Lab with WAP router installed in metal cabinet housing the tablets.

When asked about their opinion of a lecture presentation with a Tablet PC in the interactive environment provided in HP Lab, students perceived it as to be more interesting and attention catching than with ordinary PowerPoint presentation.

Students generally enjoyed using HP Tablet PCs for drawing and painting while preparing they storyboard projects or creating their 2D and 3D drawings in CAD/CAM engineering assignments. Using the pressure-sensitive pen helped them improve their artwork, and some reported that they felt that their handwriting and drawing skills had improved as result of using pen, and open their mind to new artistic possibilities.

They were also very satisfied with the ability of using tablets on field and they all reported that HP Tablet PCs and mobility associated with them made the process of heritage digitalization on the original sites possible and easier than ever before.
Exactly the same comments and level of satisfaction was observed during the lab exercises in Modeling and simulation course, when students were using tablets to monitor and control pilot plants and physical models of systems designed for the course.
 They were especially pleased with the very long battery life. However, some of them said that they were concerned during the work on the field about accidental damage and spilling of the water (rain) over Tablet PCs that might occur. They

suggested that Tablet PCs should be constructed to be able to endure harsh outside environmental conditions.

One more aspect that was appreciated among the students is the ability to work on their projects and assignments not only in HP Lab, but also from their homes on the virtual machines in the faculty private cloud on HP Server and accessible over the Internet.

Although, in this case, they did not use HP tablet PCs that are available only in HP Lab, they could use their personal laptops or desktops to work on their programs from home or any other place with Internet access.

Impact on Student learning - evidence

To measure the impact of the new teaching technology introduced with HP Tablet PCs and the rest of hardware and software innovations included in HP Lab (Smart interactive touch board, cloud computing), we have accepted natural   and self offering method to compare the figures achieved in activates like: passage rate on the courses, the average grade, course selection rate for optional courses, lectures attendance rate, etc.   before the new technology was introduced and after the introduction of the technology.

The results obtained for the course on Numeric Graphics and Animation are shown in the following figures No. 4, 5, 6 and 7. From these figures can be observed that there has been statistically significant increase in scores for the final grades and the coursework projects' scores for the course implementation when HP Tablet PC Technology was used, which indicates that students' understanding and acceptance of course material was remarkably improved with the use of HP Tablet PCs and other technology implemented in HP Lab.
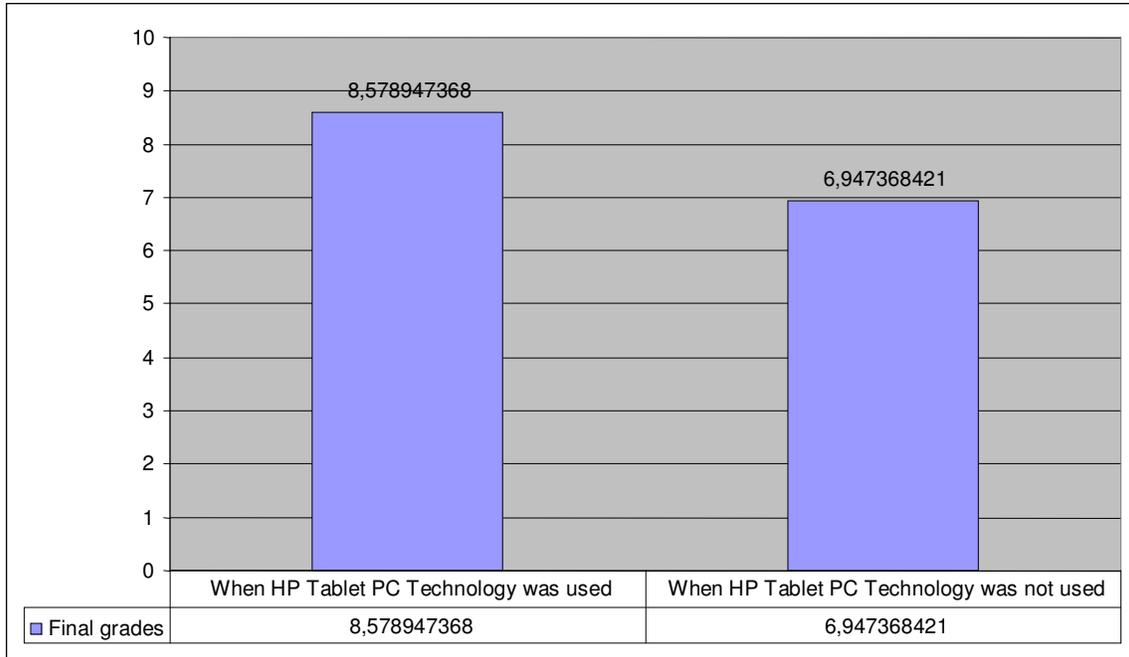
Figure No. 4: Final grades comparison chart for the Numeric Graphics and Animation course held when HP Tablet PC Technology was used with the Scores for the course beforehand
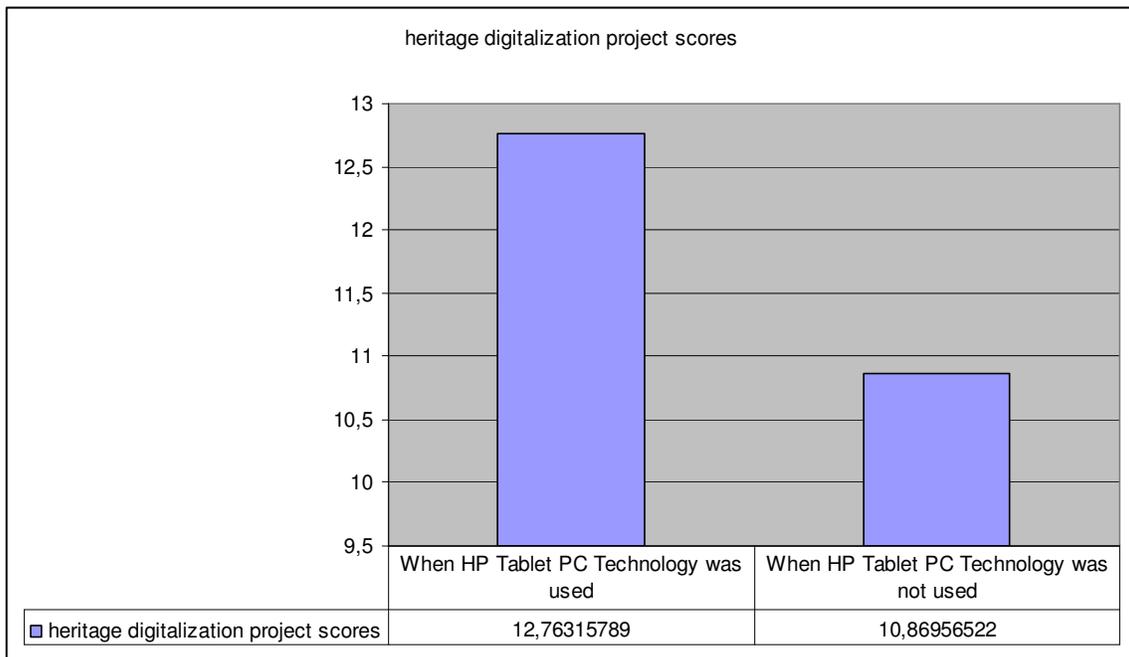

Figure No. 5: Heritage digitization project scores comparison chart for the Numeric Graphics and Animation course held when HP Tablet PC Technology was used with the scores for the course beforehand (average grade in the range 0-20)

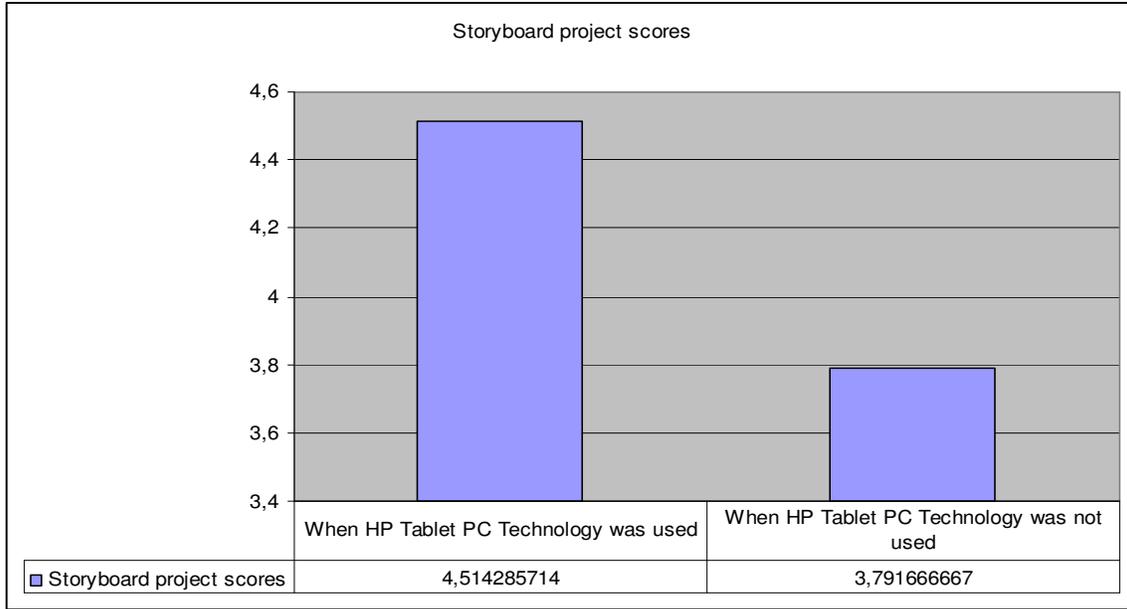| Storyboard project scores	When HP Tablet PC Technology was used	When HP Tablet PC Technology was not used
Storyboard project scores	4,514285714	3,791666667

Figure No. 6: Storyboard project scores comparison chart for the Numeric Graphics and Animation course held when HP Tablet PC technology was used with the scores for the course beforehand
(average grade in the range 0-5)

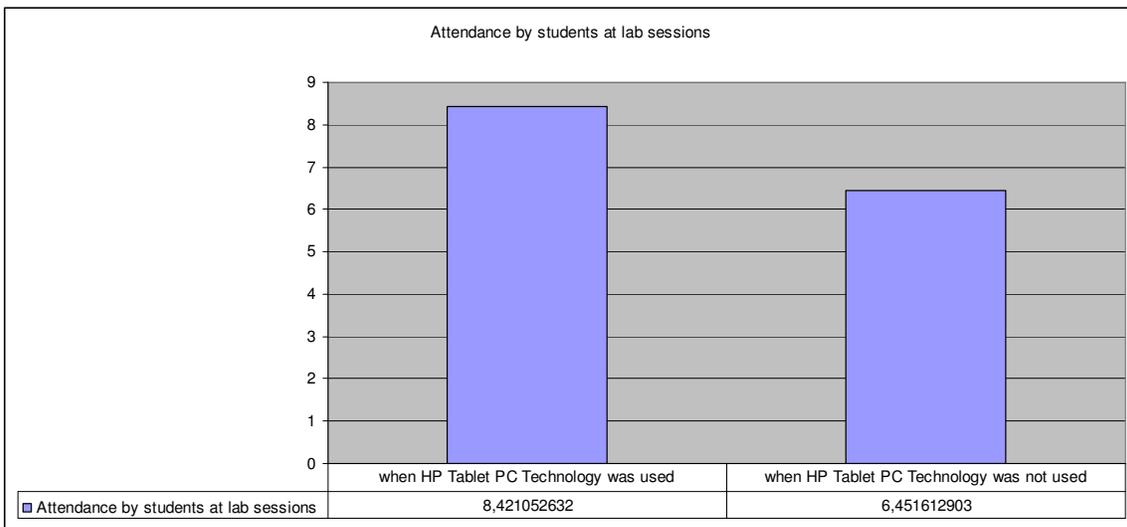| Attendance by students at lab sessions	when HP Tablet PC Technology was used	when HP Tablet PC Technology was not used
Attendance by students at lab sessions	8,421052632	6,451612903

Figure No. 7: Attendance by students at laboratory sessions for the Numeric Graphics and Animation course held when HP Tablet PC technology was used with the scores for the course beforehand
(average attendance in the lab. group of 10 students)

We have obtained the same significant increase in all mentioned success indicators for the remaining three courses as well.
It is worth of special mentioning, the impact achieved on the course CAD/CAM Engineering.

On this course, since the course is optional on Department for computing and informatics, the course selection rate has jumped from 16 students in the spring semester of 2009 to 49 students in spring semester of 2010, or more than 3 times. (See chart on Figure No. 8). This sharp increase in optional course selection is attributable to the impact achieved through the "word of mouth" between the students who attended course with new technology for the first time in 2009, and second generation in the spring 2010.
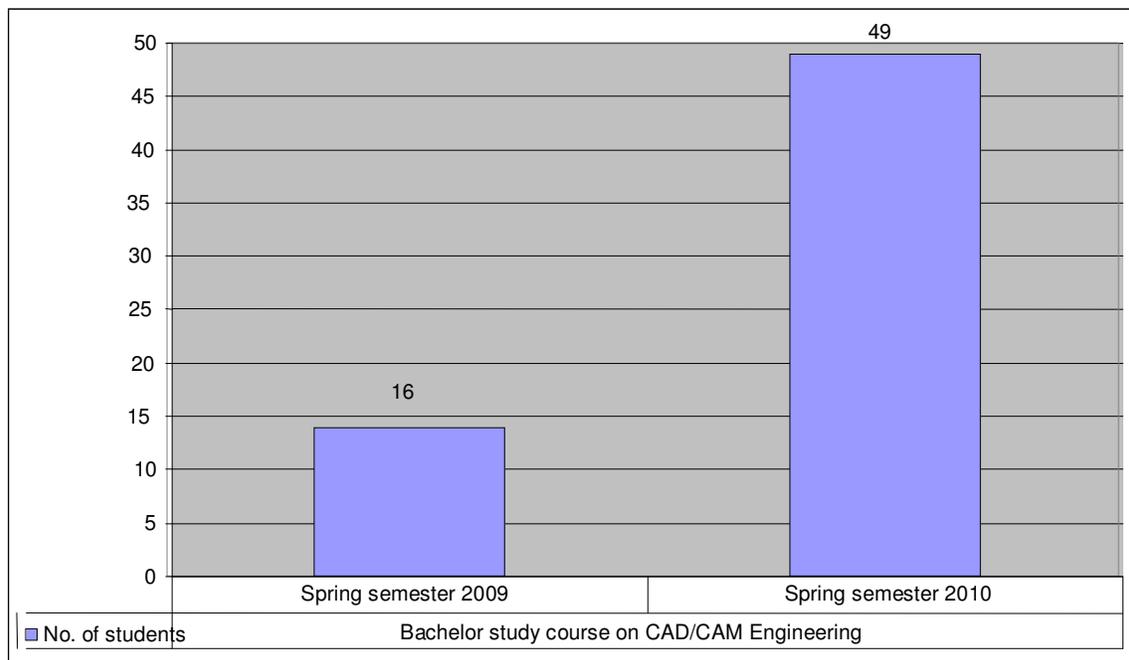.

Figure No. 8: Number of students selecting optional course on CAD/CAM Engineering at the Department of Computing and Informatics in two consecutive academic years (2009 and 2010), since new HP technology was introduced and the course delivered within HP Lab premises

Notable impact was also achieved on the Master study course on System identification when comparing the average marks in two consecutive years (spring 2009 and 2010) when the course was delivered using new teaching technology in HP Lab. The average mark (in the range 6-10) went from 7.23 in the first year of tablet PCs utilization for lecturing and lab exercises to 8.12 during the course run-up in spring 2010, e.g. has increased for almost 20%.
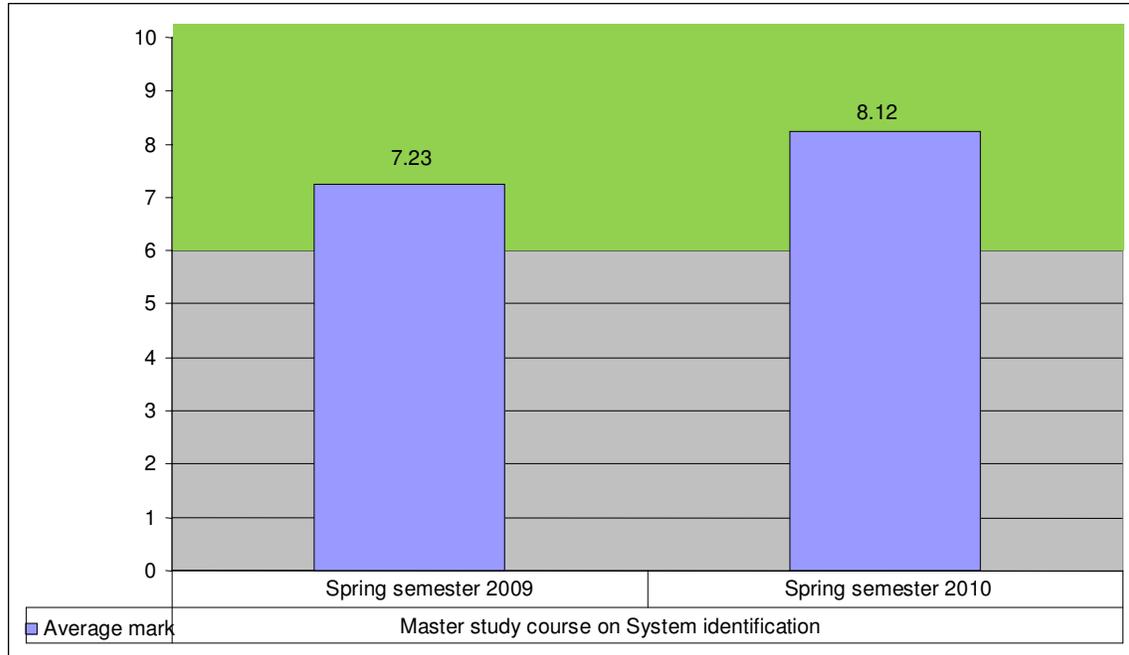
Figure No. 9: Average mark achieved in grading the students on the Master study course on System identification at Department of control and electronics in two consecutive academic years (2009 and 2010), since new HP technology was introduced and the course delivered within HP Lab premises

This increase is attributable to the fact that the course on System identification delivered in spring 2010 was much more interesting and appealing for students since the teachers on the course have had experience from previous year course (spring 2009) when technology was introduced for the first time. They had enough time to develop and prepare much more attractive teaching material and lab exercises that have utilized the advantages of the new technology like interactivity, ease of data entry, mixing theory with examples and identification models running on virtual machines in the same time, in order to illustrate the concepts taught, etc.

From these examples, it is obvious that the true impacts of the introduction of new technology in teaching have to be assessed after several years since the technology introduction, so that all effects can take place and express themselves.

Impact on Systemic Support

As mentioned in previous paragraph of the impact of new teaching technology in the case of course on CAD/CAM engineering, measuring of its effects and consequently taking systemic measures to introduce it takes longer time to follow up and observe before it can gain full systemic support within institution and academic community as a whole.

Student Quotes

Here we shall quote some of the students' most interesting and illustrative statements related to the new teaching technology they experienced while working with Tablet PCs in HP Lab:

1. I am used to work with a mouse, and this is totally new experience for me. I was skeptic in the beginning, I thought, how I could create 3D graphics without a mouse? But when I started using pen, I was surprised how easy and fast creating 3d graphics is when I have more direct control. I definitely should buy one for myself!
(Damir,   Master study course on Numeric   Graphics and Animation)

2. This tablet PC has helped me a lot to repair mistakes on my 3d model on site. Using only photos could not give me much 3d information as I needed, but when I was analyzing object on site, I could not save as much 3d information only using my photo camera.   (Jasmina,   Master study course on Numeric   Graphics and Animation)

3. It is so easy and exciting to monitor and control the plant with tablet PC, while standing in front of it in the field and observing what is going on (Nejra, Bachelor study course on Modeling and simulation)

4. With tablet PC using its pen and wireless connectivity, I can observe and collect data on site and enter them straight into program while making system identification
 (Aida, Master study course on System identification)

5. it's much lighter and have more cool functions then my old laptop, and it's much faster. Only disadvantage is smaller display, but I suppose that is because it makes it more portable. It can be packed and carried around even in a small case or bag.
 (Senad, Master study course on Numeric Graphics and Animation)

6. I like the way it can recognize different amounts of pen pressure. It is very useful in graphics application, and can't be done using mouse. (Edin, Bachelor study course on CAD/CAM Engineering).

7. I like graphics, and specially, writing with bare hand on paper. I do not really like computer graphics drawing, because I have a lot of limitations using only mouse. To overcome this problem, I usually scan my drawings with scanner and then I use Photoshop to repair this scanned sketches. This takes me a lot of time, because it is usually needed to make some repairs on paper and scan again. We had an exercise on faculty where we used Tablet PC to sketch some scenario. I was delighted how this piece of technology works! I can draw with my hand directly on monitor, and see results immediately. There is no need to scan it, because it is already in digital. And best of all, every mistake can be undone with a single click! This is 'must-have' for every professional sketcher or designer, and everyone who makes drawings with bare hand (Marko, Master study course on Numeric Graphics and Animation)

8. I thought that it has low performance because it is very small and maybe designed for portability and not usability, but I am surprised how fast I can do all my graphic works that are very performance dependent (Maja, Master study course on Numeric Graphics and Animation)

Other Outcomes

When we started to build and equip our HP Lab based on hardware and cash donation from HP Technology for teaching grant in 2008, we were so surprised how much technology was existing out there to improve the teaching process and learning outcome. We were so excited and enthusiastic to find out, select purchase and integrate as much technology as affordable from the grant, building interactive HP lab. We ended up integrating not only HP Tablet PCs, but also HP Server ML350 that enabled us to build private cloud based on virtualization technology, wireless network around campus area, internet connection to the Lab and private cloud and Smart touch screen interactive board, all that interconnected with software (MS Server 2008 with Hyper-V, several Oss, DyKnow and Wimba) for collaborative and interactive work and videoconferencing.
So our HP Lab became not only mobile but also 24/7 open and accessible (password permitted) teaching and learning environment and "science drugstore".

Initiative Challenges

The challenge that we faced while building our interactive HP Lab and installing the software tools required for the selected four courses to be held using this facility, was mainly in the limited memory and processing power that we have with HP Tablet PCs model 2710p with 2GB of main memory.
Although we have increased this memory capacity to 4 GB and upgrade operating system on tablet PCs from Windows XP to Windows 7 version for tablets and added 8 GB of flash memory on USB stick serving as bootstrap memory, we did not achieve
satisfactory performance with some software packages that we are using for these courses in lab work and project designs.

This is especially true with CAD/CAM engineering where we are using very heavy and demanding Autodesk software packages like AUTOCAD and INVANTOR, then MAYA and 3DS MAX for the course on Numeric graphics and animation and Mathworks MATLAB and SIMULINK with toolboxes for courses on Modeling and simulation and System Identification.

The way we have solved this problem in Tablet PCs memory capacity and processor speed limitations, was to introduce into HP Lab configuration HP server ML350 equipped with 16 cores and 64 GB of RAM memory with MS Hyper-V hypervisor which was used to create dozen of virtual machines within VPN network that

encompasses all tablet PCs and HP server with its virtual machines with firewalled connection to Faculty intranet and Internet.

So all "heavy" software packages were installed on these virtual machines, and Tablet PCs were used as remote terminals to these virtual machines and programs run on them.

This solution was not only beneficial for running applications within HP Lab at higher speed and with more RAM, but is also enabling students to have permanent and omnipresent access over Internet to their projects, exercises and homework assignments including their homes.

In addition to this limitation, some student complained about insufficient screen size when working on their graphics projects and assignments, claiming that 12" screen size of tablet PCs is not sufficient.

We solved this problem, at least temporally while working in the HP lab, by enabling them to send their screen on lab projector and display it on the large screen.

Initiative Visibility

Since the very beginning of the announcement that our Faculty has been recipient of HP Technology for teaching award for 2008 year, the Project team members have disseminated this not only within Faculty but also University and local media. We started immediately on creation of the web site (URL address: http://hp.etf.unsa.ba/) which is regularly updated and maintained with all news related with the grant and technology application in the education process at the Faculty.

The link to the project web site is held on Faculty main page portal to be visible to all students visiting the faculty web site, and has been included in personal web sites of all teachers included in the projects.

The members of the project team have also organized several multimedia presentations of the HP Lab and its capabilities to student population at the faculty. HP Lab is also regularly presented at annual faculty Open day.