Utilization of Tablet PCs in Electromagnetics Education

Al-Zoubi A. Y\textsuperscript{1}, George Sammour\textsuperscript{1} and Qasem M. Al-Zoubi\textsuperscript{2}
\textsuperscript{1}Princess Sumaya University for Technology, Amman, Jordan
\textsuperscript{2}Yarmouk University, Irbid, Jordan

Abstract—Tablet PCs are drawing interest as a potential tool for improving teaching and learning in engineering education. This paper reports on how engineering undergraduates perceive the effectiveness of the Tablet PCs as a teaching and learning tool. Over three semesters, students in the electromagnetic course responded to an online survey related to specific uses of Tablet PCs in their class. Responses from the students were overwhelmingly positive, but further research is essential due to the increasing availability of Tablet PCs, the lack of empirical evidence related to their effectiveness in engineering education, and their potential for improving teaching and learning.

Index Terms—Tablet PC, Mobile Technology in Higher Education, eLearning and mLearning.

I. INTRODUCTION

Electromagnetism (EM) is one of the most difficult subjects to teach, both for students and lecturers, because it requires a great deal of visualisation in order to acquire a deeper insight into the fundamental elements and underlying principles of fields and waves behaviour. The course involves a variety of complex mathematical space operators, vectors and laws that are used to solve complicated electric and magnetic field problems. It requires a strong mathematical background coupled with a three-dimensional geometrical imagination. As with many fundamental concepts, knowing the mathematical formulas is not enough for students to have a “feeling” for their applications [1]. The student needs to visualize the problem and its associated conditions to be able to solve the equations and then to understand the solutions for the variation and propagation of electromagnetic fields.

This paper focuses upon the implementation of Tablet PCs in the delivery of the introductory EM course at Princess Sumaya University for Technology. The Tablet PC is seen as a strong contender to become the technology of choice for students and faculty at leading universities as it is being well received for its potential use in the classroom, particularly with comprehensive courses like EM. The stylus-based input system, wireless capability, light weight, convertible form, and competitive price were benefits of particular interest to students. The Tablet PCs used in this study is the LifeBook T4010 Fujitsu Siemens.

The EM course was delivered in a variety of ways including annotated Microsoft journals, word document, PDF formats and sticky notes. Animations for problem formulation and solving were also presented in power point presentations formats, in addition to other forms of animations available online. A special Matlab software was also designed to simulate a Smith chart for solving transmission line and impedance matching problems. An online survey was conducted to investigate the students’ perception of the use of Tablet PCs in classroom education, and the results are discussed and evaluated.

II. TABLET PCs

Tablet PCs are quickly emerging as a powerful technology-enhanced learning tool in higher education. They are like ordinary laptops with additional special pens that permit the user to write upon its screen to form the primary input device. The pen can be used to input standard mouse-type commands as well as gesture commands and electronic ink drawing, while also facilitating the development of innovative applications by software developers [2]. This unique functionality allows users to create lecture materials using “digital ink” that can then be saved or distributed to students for review. Furthermore, digital ink allows PowerPoint presentations to become dynamic by allowing faculty members to construct and deconstruct information. Typical Tablet PCs also include built-in wireless networking hardware that allows the user to relatively easily communicate in localized ad-hoc networks or over the broader Internet. The design of Tablet PCs and its handwriting functionality, thus, challenges the way faculty and students integrate computers into their teaching and learning. Unlike laptops, Tablet PCs overcome the many barriers which are created between the students and faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the space taken by the screens which in turn blocks the faculty member when used in the classroom such as the
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student to search the text and flag important topics for future reference [3]. One of the strongest benefits to using the Tablet PC in face-face instruction is the ability to use the device as an “interactive whiteboard”. Windows Journal is an excellent program for this task and requires a short learning curve, which is one reason that faculty members are quickly adopting this program. Coupled with the ability to use digital ink for writing, drawing, and annotating, this proves to be a simple but powerful presentation tool. In fact, a faculty member could allow students to take control of the Tablet to create a collaborative learning experience. The application will not only help students retain a greater amount of information from the classroom experience, but help maintain the distribution chain of learning materials between teachers and students in a simple, effective way [3].

In addition to Windows Journal, the Tablet PC transforms PowerPoint presentations by making them more dynamic. Faculty members can create a very simple presentation for class, incorporating a few key images and questions. During class, this very simple presentation is built upon by applying digital ink to the slides. This real-time creation of slide content allows the faculty member to construct and deconstruct information right in front of the students. All of this can be saved and distributed to the students after class. Since the presentation is dynamic and builds upon class discussion, it reinforces the class session but does not replace it.

III. EXAMPLES OF TABLET PC IMPLEMENTATION IN UNIVERSITY TEACHING

Tablet PCs have slowly found their way into the higher education setting through a variety of pilot projects. The University of Washington, University of Virginia, and the University of San Diego, have all developed and deployed a lecture presentation system called Classroom Presenter in which the instructor uses a Tablet PC as a presentation device of lectures [4]. The Tablet PC is held by the instructor and wirelessly connected to a second computer driving a classroom projector. The instructor displays slides from the computer, and can write on top of them. Various navigation and control faculties were made available to promote interactive learning environments in large classes and to enable students to receive the presentation on personal devices and provide feedback to the instructor.

The University of Texas at Austin was selected by Microsoft to participate in the “Rapid Adoption Program” for Windows XP Tablet PC Edition [5]. This program enabled the School of Architecture to assess the use of Tablet PCs by both faculty and students. Results of this pilot suggest that the Tablets facilitated a “higher level of creative interaction and mobility”. The pen and slate design allowed the Tablet to be used almost anywhere and made it possible for users to capture nascent design ideas as they spontaneously emerge. The pilot participants believe that the Tablet PC technology will further enhance their creativity if it integrates more design and concept specific software.

MIT used Tablet PCs during the International Design Competition (IDC) which provides engineering students from seven top universities to engage “in an intense two-week competition focused on robot design, construction, and competition” [5]. During this event, the ability of the Tablet PC to enhance project based learning was assessed. Each student team was supplied with a Tablet PC with the Microsoft® Windows® XP Tablet PC Edition operating system. The Tablets allowed students to move around in various environments to create advanced robot designs. The Tablet PC acts like a pen and paper, so students can quickly sketch out their ideas, easily change their designs anywhere, anytime during all phases of the contest project, and finally shared these designs by projecting them onto a wall for all to view. A revision tracking program allowed each student to make changes to the design and receive feedback while keeping version control. Design versions were emailed using the wireless capability of the Tablet allowing students to continue to collaborate without the need to all be in one place at the same time.

Furthermore, many other universities are currently using Tablet PCs, including the University of Ontario Institute of Technology, Perdue University, Seton Hall University, Northeastern University, University of Illinois at Urbana-Champaign, Winona State University and Carnegie Mellon University to name a few. For example, the University of Ontario Institute of Technology (UOIT) is reported to be the first University in Canada to fully embrace the Tablet PC, which is currently used in every course at the School of Science where faculty members find Tablet PCs especially useful for presenting math and technical notations during in-class presentations [5-6]. The Tablets are used to create lectures to help students to better understand their professors’ handwriting, which may become more legible on the Tablet than the blackboard because it feels more natural. Students can concentrate on the lecture instead of trying to write down everything that the professor says because the class notes are saved and made available to the class.

A recent study at Seton Hall University has recommended that tablet technology should be pursued for those faculties with an interest in an application for which the Tablet is well-suited [7]. In particular, it seems that those fields that require freestyle drawing of diagrams, pictures and charts, as well as fields requiring the use of mathematical symbols are good areas for the use of tablets. These fields include many areas in the sciences and the social sciences, including, for example, physics, biology, chemistry, psychology and economics.

The HP Higher Education Technology for Teaching grants initiative, however, remains one of the main advocates for the use of Tablet PCs in higher education. Since 2003, the HP initiative has supported educators developing and sharing effective educational approaches and experiences for applying Tablet PCs and mobile technology into learning environments with other professors on campus and beyond [8]. Microsoft has also
launched the Tablet PC Technology, Curriculum, and Higher Education awards, with an objective to act as a catalyst to encourage educators to apply resources toward the revising, updating, and validating curriculum and pedagogy in conjunction with tablet technology in higher education [9].

IV. TEACHING ELECTROMAGNETICS

An increasing trend for lecture-based courses is for instructors to convert their lecture notes to slides that can be projected electronically. While there are many advantages to electronic projection, a large drawback is the loss of interactivity and spontaneity that can result. The use of a Tablet PC by the instructor promises to overcome this difficulty. The Tablet PC, combined with appropriate software, enables the instructor to “write and draw” using digital ink. This allows the instructor to provide colour attentional marks, annotations and drawings as the lecture progresses. Examples of the use of digitally inked slides for classroom teaching of the electromagnetics course are shown below. The first example, Microsoft’s Windows Journal software that enables the lecturer to use their stylus pen to handwrite, colour code and edit their class and homework notes on the Tablet PC screen, as shown in Fig. (1). This Journal format was converted from word-document lecture notes.

The second example is a sticky note used by the professor to explain Maxwell’s equations, as shown in Fig. (2), possibly with short duration embedded voice of the professor. These equations can be later converted to text utilizing the hand-writing recognition capability of the Tablet PC, handed over to students for further studies, or posted into the course website.

The internet can also be an effective source of lecture material when using a Tablet PC for lecturing. The professor can display online animation illustrations, such as 3-dimensional electromagnetic waves propagating in media of various electronic and magnetic properties. These waves can be simple plane waves as shown in Fig. (4), or circularly polarized waves as shown in Fig. (5). The students find these animation particularly useful as they are easily visualized and imagined, while they save the professor time which may be spent to draw an construct, needless to say that some problems cannot be animated by traditional means.

The instructor can also write in the slides as the simulation progresses, providing additional explanations to students.

![Figure 1 Microsoft journals containing a lecture notes with explanations as a lecture progresses.](image1)

![Figure 2 Sticky notes depicting Maxwell’s equations.](image2)

![Figure 3 Power point Presentation for construction a problem to find the electric field at a point \( P(0,0,h) \) due to a ring charge distribution.](image3)

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![Figure 4 Electric field due to charged ring](image4)

![Figure 5 Circularly polarized waves](image5)
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A further simulation facility was utilized for teaching by a Tablet PC is computer generated Smith chart used for transmission line and microwave circuit problem solving by graphical means. A Matlab software program was designed to perform specific tasks according to a required user pushbutton input. These tasks vary from a simple step-by-step plot of to a complicated design of an impedance matching network. The results obtained show improved numerical accuracy, reduced time, clear graphical presentation compared to the traditional problem solving means. The software also enabled the instructor to use the Tablet PC to explain, with annotation, how the Smith chart is designed, constructed and implemented for problem solving, as shown in Fig. (6).

The simulation program was put to use to solve a multitude of transmission line and matching problems as shown in Fig. (7). In particular, emphasizes were focused on solving fairly complicated situations involving tuning stubs where the length and distance from the load are required. Comparisons with traditional Smith chart techniques show that students are usually satisfied with simulated solutions of such rather complicated problems, primarily the issue of time saving.

V. STUDENT SURVEY RESULTS

The Tablet PC was implemented in teaching the electromagnetic course over 4 semesters. An online survey at http://www.psut.edu.jo/sites/zoubi/questionnaires/Tablet_PC.html was conducted to investigate the students’ perception and acceptance of the use of Tablet PCs in classroom education. Over 100 students have taken this course, but with a gradual implementation of the various aspects of the Tablet PC facilities. Over 69% of students rated using Windows Journal, Power Point, Word to create lecture notes positively and 77% rated drawing diagrams, charts, and graphs positively, while only 50% and 46% of the students found writing equations and electronically distributing in class, tablet-created lecture notes useful respectively. Power point presentation was, however, rated by students the most useful Tablet PC presentation facility offered in teaching the electromagnetic course, while PDF and voice recognition were most unpopular as shown in Fig. (8).
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Over 57% of students however agreed to the fact that the use of the Tablet PC increased their interaction with the instructor, 57% where more interest in the subject of the lecture but only 38% found the Tablet PC enhanced their understanding of the lecture. Still, 74% of students rated the use of the Tablet PC valuable in terms of teaching and learning and 66% felt comfortable with its use. In addition, 88% of students recommended integrating Tablet PCs into other courses within the department, 84% wanted the university to continue to provide a Tablet PC option for faculty and 73% recommended the university to begin offering a Tablet PC option to students.

CONCLUSIONS

The usefulness of Tablet PCs use in teaching electromagnetic course was described and evaluated. Particularly, the difficulty in dealing with equations, diagrams, animations and simulations simultaneously was discussed and evaluated. The results of an online survey indicate that Tablet PCs make the delivery of the course simpler, making the input timely, and aid in a complete transfer of ideas to students. The Tablet PC also allowed for greater ease of lecture delivery, specifically in allowing the lecturer to import into the lecture graphic simulations and animations using the fly internet images and computer simulations as well as power point presentations. These lectures can be saved and posted on an eLearning platform or the professor website for students’ future reference.

The results of student perception and acceptance of Tablet PC implementation for lecture delivery in a blended learning environment indicate that tablet technology for students should be pursued for teaching the electromagnetic course, and should be extended to other simpler courses with large students’ attendance and with application for which the tablet is well-suited. In particular, courses that require drawing of diagrams, pictures and charts, as well as courses requiring the use of mathematical symbols and equations, problem formulation, animation and simulations. The results are consistent and provide reliable pointers towards the usefulness of Tablet PCs for faculty at the university level. The ultimate goal of the study is to investigate the possibility to provide individual faculty members at Princess Sumaya University for Technology with technology-enhanced learning tools to assist them in their educational mission.

REFERENCES


AUTHORS

A. Y. Al-Zoubi is dean of scientific research at Princess Sumaya University for Technology, Amman, Jordan (e-mail: zoubi@psut.edu.jo).

G. Sammour Princess Sumaya University for Technology, Amman, Jordan (e-mail: gsammour@psut.edu.jo).

Qasem Al-Zoubi Yarmouk University, Irbid, Jordan.

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