Development of eBooks to Enhance Electronics Instrumentation Learning at the Tecnológico de Monterrey

Graciano Dieck-Assad
Tecnológico de Monterrey, Monterrey, NL, México, graciano.dieck.assad@itesm.mx

Sergio Camacho-León
Tecnológico de Monterrey, Monterrey, NL, México, sergio.camacho@itesm.mx

Matías Vázquez-Piñón
Tecnológico de Monterrey, Monterrey, NL, México, a00783236@itesm.mx

Adrian D. Losoya-Leal
Tecnológico de Monterrey, Monterrey, NL, México, a00790279@itesm.mx

ABSTRACT

Design of eBooks has ignited a new learning tool for new generation engineering students in many subject areas. EBooks are usually classified according to the level of interaction with the reader, navigation scheme and parallel accessories available such as review activities, annotated bibliography, capstone projects, simulation practices, interactive glossary, external links, and multimedia content like animations, videos and audio files, among other resources. This paper illustrates the experience of using eBooks sponsored by the *Editorial Digital del Tecnológico de Monterrey* in adding complementary e-tools to the learning process at the School of Engineering and Information Technology (EITI) of Tecnológico de Monterrey. The paper discusses the experience of two eBooks in Electronics, Microelectronics and Instrumentation fields, which have been used in graduate and undergraduate courses at the Electrical and Computer Engineering Department.

Keywords: eBooks, Electrical Engineering Learning, Educational Technology, Computer Aided Instruction, Electronic Learning.

RESUMEN

El diseño de libros electrónicos o eBooks ha brindado una nueva herramienta de aprendizaje para las nuevas generaciones de estudiantes de ingeniería en muchas areas diferentes. Los eBooks normalmente son clasificados de acuerdo al nivel de interacción con el lector, sus esquemas de navegación y los accesorios paralelos disponibles, como son actividades de repaso, bibliografia anotada, proyectos de reafirmamiento, prácticas de simulación, glosario interactivo, enlaces externos y contenido multimedia como son animaciones, videos y archivos de audio, entre otros recursos. En este artículo se ilustra la experiencia del uso de eBooks patrocinados por la *Editorial Digital del Tecnológico de Monterrey* como adición complementaria de herramientas electrónicas al proceso de aprendizaje en la Escuela de Ingeniería y Tecnologías de Información (EITI) del Tecnológico de Monterrey. En el artículo se lleva a cabo la discusión de dos eBooks en los campos de la Electrónica, la Microelectrónica y la Instrumentación, y que han sido usados en cursos tanto de carrera profesional, como de posgrado en el Departamento de Ingeniería Eléctrica y Computacional.

Palabras claves: Libro electrónico, Aprendizaje en Ingeniería Eléctrica, Tecnología de la Educación, Instrucción Asistida por Computadora, Aprendizaje Electrónico.

1. INTRODUCTION

Electronics and Microelectronics Engineering have been highly strengthened by advances in micro and nanotechnology, which have provided a wide range of applications and solutions in benefit of mankind. Particularly, the miniaturization and integration of complete systems into integrated circuits have provided a wide spectrum of different problem solutions to develop procedures and devices in telecommunications, transportation systems, bioengineering, biotechnology, instrumentation, automation, mechatronics, information systems, computer systems, automotive electronics, avionics and process control systems.

The vast variety of new electronic devices available on a day-to-day basis, which are manufactured in very highly integrated fashion, has produced systems that fulfill demanding necessities of our industrialized society. Moreover, the electronic instrumentation has evolved in such way that many innovations and new circuit design strategies are used to synthesize more intelligent and simpler solutions to complex problems. On the way to achieve a better understanding of concepts and to enhance the learning process of both students and self-practitioners, a self-paced gadget-oriented tool is proposed to consolidate and validate the conceptual and practical aspects of engineering learning. This tool, called eBook, is not only an electronic version of a printed book that you can access and read (by linear navigation) through an electronic reader or tablet pc. It can additionally include a set of gadgets and accessories that allow: a complete selection of entry point, annotated bibliography with WEB links, resources such as interactive appendices, interactive glossary, simulation activities, capstone projects, and other technology oriented accessories. EBooks also allow to include multimedia content to make the learning process more attractive for the reader since such multimedia content can be used as animated examples, interactive quizzes, audible explanations, demonstration videos, among other possibilities. Furthermore, since eBooks are distributed as an electronic resource, the cost of development is considerably reduced, which is translated to a reduction of costs for the reader compared to a traditional printed book, and are available for purchase worldwide through the editorial website. This full combination of capabilities has given eBooks a special consideration in engineering learning at the Tecnológico de Monterrey.

The use, awareness, discussion and application of eBooks in higher education have been addressed by educators, researchers and academicians during the last decade in efforts to enhance efficiency in the process of computer-based learning. For example, a study performed to students that use eBooks on mobile devices has been reported (Lam et al., 2009). The results of monitoring two teams reveal that educational technology has a strong potential to enhance learning at Universities, even though a number of challenges need to be addressed, especially for long term users. In other work it was investigated the use and usability of eBooks in academic research environments (Anuradha and Usha, 2006). The study shows that students tend to use this new technology more often than faculty and staff, however the use of eBooks still appears to be low compared to traditional books. Intensive awareness campaigns are required to educate users about the benefits and advantages of this new computer-based learning technology. An on-line survey of eBook awareness and usage level in a British academic library it is also reported (Abdullah and Gibb, 2006). In this work, it is shown that the eBook awareness and usage were both low; more than 50% of the students did not know about their availability and did not used them at all. Non-users mentioned the lack of advertising or promotion of those new learning technologies. Also, it was reported a survey of about 16,000 academicians which discloses that the biggest advantage of eBooks is their online access and search-ability features (Jamali et al., 2009). Furthermore, a study to identify the usage pattern of eBooks at the Faculty of Computer Science and Information Technology at the University of Malaya was performed (Roesnita and Zainab, 2005). Their results indicate that the students have a positive attitude towards the eBook service, however, the level of eBook usage is still low (39%). An interesting study of the taxonomy for eBook readers categorizing their behavior it was described (Chou et al., 2010) and was also reported a study about the attitudes and issues for lecturers at the UK in order to provide an improvement platform to design eBook readers for their future application in education (Wilson, 2003). In the January 28, 2013 edition of the Chronicle of Higher Education, J. R. Young (Young, 2013), addresses the need of a new category for publisher's digital products such as eBooks. Finally, a survey to over 5500 students at the Tecnológico de Monterrey revels that 34% of them buys at least one eBook per semester to fulfill and complete their course work activities (Innov@te, 2012).

This paper describes the experience of using the following eBooks at the Engineering and Information Technologies School (EITI) at the Tecnológico de Monterrey, Monterrey campus:

1. Simulation Practices for Electronics and Microelectronics Engineering, Vol I: Networks, Electronics and Instrumentation (Dieck and Vázquez, 2012).
2. Simulation Practices for Electronics and Microelectronics Engineering, Vol II: Digital Microelectronic Circuits and CMOS Analog Microelectronics (Dieck and Vázquez, 2013).

Such works are published by the *Editorial Digital del Tecnológico de Monterrey*, in Monterrey, México.

2. EBOOK CLASSIFICATION

The meaning of the term "e-book", in full, electronic book, and variously known as eBook, digital book, e-edition or e-text, has continuously evolved since its first notorious use in 1971 (Hart, 1992). In general, modern eBooks are defined as non-periodic digital publications with unique identifiers for metadata records, which can, in turn, contain text, graphics, images, sound and even videos (Enciclopædia Britannica Online Academic Edition, 2013; Gardiner and Musto, 2010; Merriam-Webster Online Dictionary, 2013).

By its very digital nature, eBooks are intended to be consulted electronically and thus are a technology-based tool. According to how they are read, eBooks can be classified as:

- **WebBooks:** These eBooks can be read or downloaded from the Internet and only require a personal computer and appropriate reading software.
- **PalmBooks:** These eBooks can be downloaded from the Internet and read in a handheld device by using appropriate reading software.

Moreover, recent advances in display technologies, such as the electronic paper (a.k.a. electronic ink) (Paulson, 2008; Lu and Wey, 2011a; Lu and Wey, 2011b), are boosting the ease and functionality of information access for readers.

There are also different ethical, economic, legal and social aspects surrounding these technological resources; which are mainly related to the protection of intellectual property and digital rights management (DRM) (Digital Millennium Copyright Act). Likewise, due to the large number of companies that are developing devices for reading eBooks nowadays, there are numerous file formats available in the market. Table I summarizes the most common formats for eBooks and illustrates some of their similarities and differences in regards to DRM, technology and file extensions.

Table I: Comparison of eBook formats

Format	DRM	Technology	Extensions
Mobipocket/Kindle	Yes	HTML 3.2	.mobi, .prc, & .azw
ePub	Yes	Open eBook & XHTML 1.1	.epub
eReader/PDB	Yes	PML	.pdb
PDF	Yes	ISO 32000	.pdf

The eBooks of the present study (Dieck and Vázquez, 2012; Dieck and Vázquez, 2013), as well as other published works by the Editorial Digital of the Tecnológico de Monterrey, were written by Professors from this institution and are available initially as WebBooks, and in transition to Palmbooks, (in PDF and ePub formats). Furthermore, these eBooks have been developed with the explicit intention of containing:

- Quality content based on the institutional curriculum.
- Attractive instructional design with access to content updates.
- Innovative use of technology at an affordable price.

3. SIMULATION PRACTICES

The eBook: *Simulation Practices for Electronics and Microelectronics Engineering* provides a guide for SPICE-based simulation sessions. The entry page of this eBook is shown in figure 1. It begins with the very elementary topics covered in electric circuits or electric networks courses such as simulation of passive networks including RC, RL and RLC networks, where the full simulation process is explained in order to guide the reader through the capture, setup and running procedure. It continues with more intermediate topics covered in applied electronics and instrumentation. With this foundation, the eBook closes with advanced topics in microelectronics (both analog and digital). Blue prints for the Integrated Circuit (IC) chips can be obtained by students and practicing engineers.

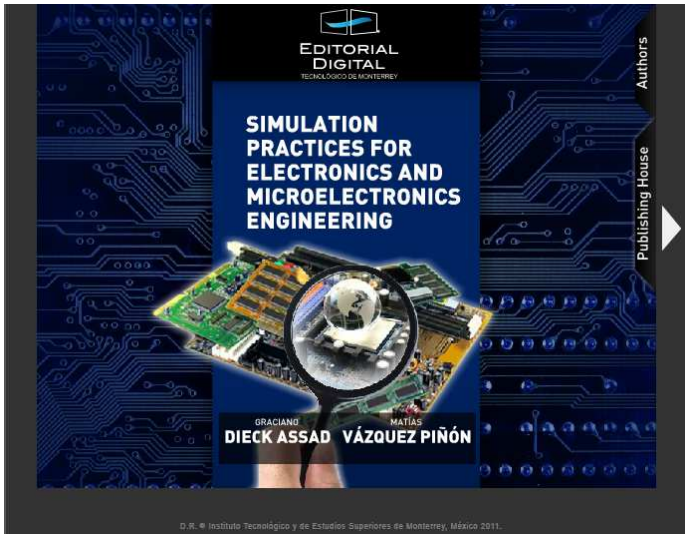

Figure 1: ***Entry page of Simulation Practices for Electronics and Microelectronics Engineering*** **(Dieck and Vázquez, 2012; Dieck and Vázquez, 2013).**

The main objective of this eBook is to establish a solid instructional platform about simulation procedures and techniques, which are standardized around the SPICE program. The eBook is a companion tool for learning electronics and microelectronics design through college. It covers most of the important areas in electrical engineering: from circuit networks, basic electronics and electronic instrumentation, and ends with the microelectronics section that includes the layout and design file generation. A general conceptual map and an index are available to allow the user a non-linear reading scheme, as shown in figure 2 and in figure 3.

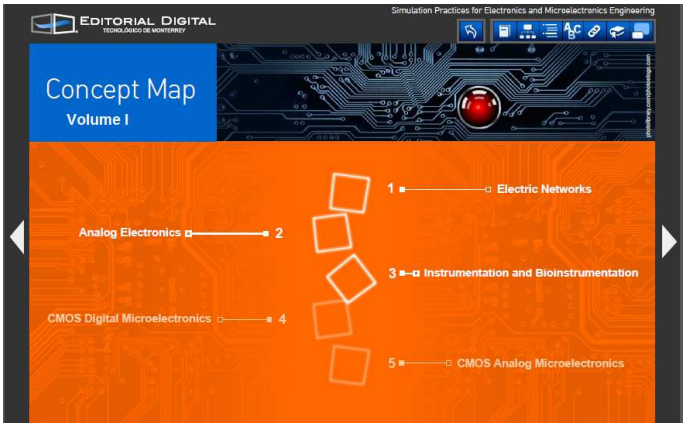

Figure 2: Concept Map for volume 1 of ***Simulation Practices for Electronics and Microelectronics Engineering*** **(Dieck and Vázquez, 2012).**

Figure 3: Index page (part I) for Volume I of *Simulation Practices for Electronics and Microelectronics Engineering* (Dieck and Vázquez, 2012).

The eBook also includes support sections that allow the reader to study or review: the annotated concepts, formulas and models, the annotated specialized bibliography, the basic SPICE simulation procedures, the fundamental printed circuit board (PCB) layout techniques, and some CMOS process MOSFET model files. The eBook supports simulation practices pertaining to the following courses:

1. Electric Circuits, Electric Networks and Electric Circuits Laboratory
2. Electronics, Applied Electronics and Electronics Laboratory
3. Instrumentation and Bioinstrumentation
4. Microelectronics and CMOS Analog Microelectronics
5. Design of Digital Integrated Circuits and Digital Integrated Circuits
6. Integration Projects in Electronics and Microelectronics Technology.

4. STUDENT CLASS EXPERIENCES

The volume I of *Simulation Practices for Electronics and Microelectronics Engineering* (Dieck and Vázquez, 2012), has been used successfully in a graduate Instrumentation course at The Tecnológico de Monterrey, Monterrey campus. The results of its implementation are shown as follows:

The first part of the graduate Instrumentation course involves the integration of analysis and design techniques to develop specialized electronic circuits for instrumentation data acquisition systems, which initiate the signal flow from the transducer terminals to the input port of the signal conversion system. The eBook was used as a core for the electronic instrumentation activities that consisted of the following:

1. Activity 3-1, Introduction to the simulation platform by analyzing a simple CMOS inverter circuit.
2. Activity 3-2, Analysis and design of Basic operational amplifier configurations.
3. Activity 3-3, Analysis and design of a zero and span instrumentation circuit using OpAmps.
4. Activity 3-4, Analysis and design of an instrumentation amplifier for instrumentation channels.
5. Activity 3-5, Analysis and design of a current loop V to I and I to V conversion/transmission circuit.
6. Activity 3-6, Analysis of a sample and hold amplifier to recover sampled data signals using a CMOS analog switch.

Those six practice sessions were performed in parallel to the following weekly activities: 1 hour lecture, 20 minute individual quiz, self-study on-line quiz (outside classroom activity) and a project related group consulting session.

Table II illustrates a change in time dedicated by the student to the course before and after the introduction of the eBook in the fall of 2012. The table shows that before fall 2012 the average time dedicated by the students to the course was about 8.8 hours/week. With the introduction of the eBook, results show that students dedicated 6.3 hours/week to the instrumentation course. The number of students attending the course was 13, 25 and 13 for the fall 2011, spring 2012 and fall 2012 semesters, respectively. All the students were engineering graduates studying a master's graduate program at the Tecnológico de Monterrey, Monterrey campus (Tecnológico de Monterrey Registrar, 2012).

The 28.4% reduction in the student's time dedication to the class opened the opportunity of developing a midterm innovation project with several electronic instrumentation topics and state of the art literature revision. This innovation project was performed using a recently inaugurated "Innovation Gym" at the engineering school, where the student teams developed regular meetings with the consulting engineer (the instructor) who was the main client for each project proposal.

Table II: Hours of dedication from fall 2011 to fall 2012

Semester	Use of eBook	Dedicated hours/week	Number of opinions
Fall 2011	No	9	8
Spring 2012	No	8.6	18
Fall 2012	Yes	6.3	8

Table II: Hours of dedication from fall 2011 to fall 2012

Also, interaction rubrics were developed for the simulation practices from the eBook and for the project term interactions performed by teams (2 or 3 students) via the Blackboard platform of the Sistema Tecnológico de Monterrey (Sistema Tecnológico de Monterrey, Blackboard Platform, 2012).

5. CONCLUSIONS

A successful experience using eBooks in a graduate instrumentation course at the Tecnológico de Monterrey has provided additional time to students for working in a term project where innovation, simulation and implementation phases are required. A 28.4% reduction in student's time dedication to the class was obtained from the fall 2011/spring 2012 sessions to the fall 2012 session. This gives us the opportunity to develop a midterm innovation project where the student teams develop: state of the art literature revision, term topic selection, justification, objectives and specification delimitation, analysis and simulation, and conclusions. These projects were developed in parallel to the consulting group meetings at the Engineering school's Innovation Gym of the Tecnológico de Monterrey, Monterrey campus.

As any other technology-based tool, eBooks have special requirements related to format compatibility across hardware platforms and digital rights management that have to be addressed during their development stage in order to be successfully adopted as an effective learning resource; but ultimately, this multimedia format of instructional design has proven to help students to reason about academic content at a much deeper level than it can be achieved through the exclusive use of traditional resources, such as lectures and printed texts; as well as to strengthening their skills in the use of information technologies, which are of paramount importance in modern society.

The Editorial digital of Tecnológico de Monterrey has multiplied the students' options since 2010 with the introduction of new eBooks suitable for engineering graduate and undergraduate credit courses and continuing education workshops. At least 34% of students at the Tecnológico de Monterrey used at least one eBook in classes during 2011/2012 academic years. The trend in e-learning at our engineering school has been enhanced

thru the introduction of eBooks and other digital media materials using the educational model of The Tecnológico de Monterrey.

REFERENCES

Abdullah, N., and Gibb, F. (2006). "A survey of e-book awareness and usage amongst students in an academic library". *Proceedings of International Conference of Multidisciplinary Information Sciences and Technologies*, Merida, Spain, 25-28 October.

Anuradha, K.T., and Usha, H.S. (2006). "Use of e-books in an academic and research environment: A case study from the Indian Institute of Science". *Program: electronic library and information systems*, Vol. 40, No. 1, pp 48-62.

Chou, S.C., Stu, J., Lin, Y., and Hsieh, W.T. (2010). "Toward Computer-Based Learning: A Taxonomy of Ebook Readers". *2nd International Conference on Computer Engineering and Technology (ICCET)*, April 16-18, Vol 2. pp V2-431-V2-434.

Dieck-Assad, G., and Vázquez-Piñón , M. (2012). "Simulation Practices for Electronics and Microelectronics Engineering, Vol. I: Networks, Electronics and Instrumentation". Editorial Digital del Tecnológico de Monterrey, (2012).

Dieck-Assad, G., and Vázquez-Piñón, M. (2013). "Simulation Practices for Electronics and Microelectronics Engineering, Vol. II: Digital Microelectronics and CMOS Analog Microelectronics", Editorial Digital del Tecnológico de Monterrey, (2013).

Digital Millennium Copyright Act, 112 Stat. 2863, 17 U.S. Code 1201-1205.

Encyclopædia Britannica Online Academic Edition. (2013). e-book (computing) – Britannica Online Encyclopedia, http://0-www.britannica.com.millenium.itesm.mx/EBchecked/topic/1235205/e-book

Gardiner, E., and Musto, R.G. (2010). "The Electronic Book". In Suarez, Michael Felix, and H. R. Woudhuysen. The Oxford Companion to the Book. Oxford: Oxford University Press, p 164.

Hart, M. (1992). "The History and Philosophy of Project Gutenberg". Project Gutenberg Literary Archive Foundation , http://www.gutenberg.org/wiki/Gutenberg:Project_Gutenberg_Literary_Archive_Foundation

Innov@TE. (2012). "Uso de Dispositivos Móviles por los Estudiantes del Tecnológico de Monterrey". *Centro Innovate de la Universidad Virtual del Tecnológico de Monterrey*, October-November 2012.

Jamali, H.R., Nicholas, D., and Rowlands, I. (2009). "Scholarly e-books: the views of 16,000 academics: Results from the JISC National E-Book Observatory", *Aslib Proceedings*, Vol. 61, No. 1, 2009, pp 33-47.

Lam, P., Lam, S.L., Lam, J., and McNaught, C. (2009). "Usability and usefulness of eBooks on PPCs: How students' opinions vary over time". *Australasian Journal of Educational Technology*, Vol. 25, No. 1, pp 30-44, http://www.ascilite.org.au/ajet/ajet25/lam.html.

Lu, C.M., and Wey, C.L. (2011). "A Controller Design for Color Active-Matrix Displays Using Electrophoretic Inks and Color Filters". Vol.7, No.9, pp 482-489.

Lu, C.M., and Wey, C.L. (2011). "A Controller Design for Micro-Capsule Active Matrix Electrophoretic Displays". *Journal of Display Technology*, Vol.7, No.8, pp 434-442.

Merriam-Webster Online Dictionary. (2013). Ebook: Definition and More from the Free Merriam-Webster Dictionary, http://www.merriam-webster.com/dictionary/ebook

Paulson, L.D. (2008). E-Paper Soon To Be in Living Color, Computer , vol.41, no.4, p. 20.

Roesnita, I., and Zainab, A.N. (2005). "The Pattern of eBook Use Amongst Undergraduates in Malaysia: A Case Of To Know Is To Use". *Malaysian Journal of Library & Information Science*, Vol.10, No. 2, Dec 2005, pp 1-23.

Sistema Tecnológico de Monterrey, Blackboard Platform. (2012). D.R.© ITESM, DTI. Ave. Eugenio Garza Sada 2501 Sur Col. Tecnológico C.P. 64849, Monterrey, N.L. México.

Tecnológico de Monterrey Registrar. (2012). TE-4001-Instrumentation, Monterrey campus, fall 2011, spring 2012 and fall 2012.

The Association of American Publishers (2013). AAP eBook Report, http://www.merriam-webster.com/dictionary/ebook

Wilson, R. (2003). "E-book readers in higher education". *Journal of Educational Technology Society*, Vol. 6, No. 4, pp 8-17.

Young, J. R. (2013). "Don't Call Them Textbooks, Publishers' latest digital products may deserve a category of their own". *The Chronicle of Higher Education*, January 28.

Authorization and Disclaimer

Authors authorize LACCEI to publish the paper in the conference proceedings. Neither LACCEI nor the editors are responsible either for the content or for the implications of what is expressed in the paper.