



Development of a Mobile App for Engineering Economics

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Development of a Mobile App for Engineering Economics*

Abstract: This paper presents the development and the preliminary assessment results of a mobile app for the Engineering Economics course. The mobile app consists of 5 tabs: E-book, calculator, reference tables, conceptual questions and practice problems. The E-book is a summary of the key concepts of Engineering Economics. The calculator provides functions to solve basic engineering economics problems with formulas. The tables allow the users to compute discrete compound interest factors. The conceptual questions give the users an opportunity to review and quiz key concepts. The practice problems generate problems with random parameters allowing learners to practice as much as they want. The same mobile app has been developed for both Apple iOS and Google Android platforms. We will release our developed apps to the public after full assessment in the College of Engineering at Lamar University. It will give students more opportunity to learn and practice Engineering Economics whenever they have spare time. The preliminary assessment results in Fall 2012 semester are presented in this paper. Surveys and interviews are conducted with randomly selected students to get a better understanding of the impact of the mobile app. The authors are now in the process of transforming the app into game-style. Further development and improvement with formative assessment is planned in the next three years.

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1. Introduction

Engineering Economics is a core class in engineering and is often required in engineering curriculums. The material taught through this class is also covered on the Fundamentals of Engineering (FE) exam, which is the first step to be a Professional Engineer (PE). This course teaches skills required to analyze profits, costs, and the time value of money through many different methods and devices. The challenge for educators is that engineering economic analysis is primarily concerned with problem solving methods that seem to be non-intuitive for many students. There have been proposal for alternative teaching methods including Internet integration with other courses¹, and a mechanics analysis of the cash flows². Another challenge is that students have a misconception that *Engineering Economics* is not related to the field of engineering. However, the survey results have shown that our graduates believe that it is one of the most useful courses in the engineering practice. Therefore, it is critical to design innovative instructional approaches for this course to improve student retention in engineering.

Based on our needs assessment, the students need: 1) more explanation of abstract concepts

with better illustrations and practical scenarios; 2) more channels for interaction with the instructor and classmates; 3) ubiquitous access to learning materials at their own pace. Smartphone apps can potentially help busy students by providing ubiquitous access to multimedia learning materials along with more channels for interaction.

A smartphone is a mobile phone that offers more advanced computing ability and connectivity than a contemporary basic feature phone. Smartphones run complete operating system software, providing a platform for application developers. Apple iOS and Google Android are two examples of popular smartphone platforms. Today, smartphones offer multi-touch screen interfaces featuring many small apps with different functions. Some of these small apps are educational applications via online market places such as the Android Play store and the Apple app store. A search in the Apple app store returns one simple Engineering Economics app with only six problems. A search in the Android Play store yields only one simple outdated app, last updated in March 2009. Both were developed for assisting students as a simple reference for Engineering Economics equations and calculations only.

The rest of the paper is organized as follows. Section 2 introduces research background information. Section 3 explains the current progress of our mobile app for Engineering Economics. Section 4 discusses the preliminary assessment of the current app. Section 5 concludes the paper and suggests future work.

2. Research Background

Research indicates that students have a difficulty in developing the deep-level understanding required to achieve insight into the principles and rules underlying specific facts or results³. Engineering Economics concepts are not intuitively clear for engineering students since they are required to understand the concept of giving different values to the same amount of money if considered at different times. To address the difficulties, instructors have been pursuing different teaching aids such as project-based learning⁴ and simulation and multimedia to help convey these concepts⁵.

Multimedia is defined as ‘presenting both words (such as spoken or printed text) and pictures (such as illustrations, photos, animation, or video).’ The theory of multimedia learning suggests that ‘people can learn more deeply from words and pictures than from words alone’⁶. Mayer’s cognitive theory of multimedia learning, Sweller’s cognitive load theory and Schnotz’s integrative model of text and picture comprehension focus on the process by which people build mental representations from words and pictures. Our design of the smartphone apps will follow the instructional design principles derived from the cognitive load theories.

Technology used for teaching Engineering Economics: Since personal computers became available in homes and schools, development in educational technology has progressed at an accelerated pace⁷. The types of technology that are now being used in Engineering Economics instruction fall into one or more of the following categories: 1) Specialized financial calculators⁸; 2) Spreadsheets (MS Excel); 3) Instructional software, including simulators and modeling software⁹; and 4) Internet applications for class management¹⁰. Engineering Economics learning resources found on the Internet can be classified as: 1) Web pages, 2) Video lectures, 3) Multimedia PowerPoint presentations, d) Electronic books¹¹.

Smartphone Apps: A small application that runs on a smartphone is called an app. For different operating systems (platforms), the app development tools are different. For example, Apple apps are typically developed within the X-code environment in Objective-C programming language and can be deployed to iPhone, iPod Touch or iPad. Another example, Android apps, are typically developed in Java language and deployed to Android devices. Other smartphone systems include Symbian and Windows Mobile. Typically, one app compiled and built for one platform cannot be used on a different platform. Several cross-platform development tools, such as PhoneGap¹², exist for some types of mobile apps.

No suitable apps can be found in the Android Play or Apple app stores to assist Engineering Economics learning in a comprehensive way. Consequently, little has been done to help us understand how the smartphone apps can be best used to assist the learning process and how this understanding can help developers to design better apps to assist learning. This is the key research problem that this project will address.

3. Development of the Mobile App

The authors developed the first version of the Engineering Economics mobile app to reinforce and improve the understanding of fundamental principles of Engineering Economics through the use of the smart phone apps outside the classroom individually or collaboratively. The example topics include time value of money, cash flow modeling, applications of interest rates, decision making, effects of taxes and depreciation.

The current app consists of 5 tabs/sections:

- E-Book: This is an E-Book consisting of several sections of key notes relevant to materials covered in this course (Figure 1).
- Calculator: This consists of 10 calculators specific to different types of common problems (Figure 2).
- Tables: This can generate interactive reference tables. Once the user enters the necessary parameters, a reference table of compounding interest factors is generated.

One may use the electronic table instead of looking up a reference book (Figure 3).

- Concepts: This is a list of key concepts. One may touch a concept and be prompted with a question to check one's understanding of this concept (Figure 4).
- Practice: This is a list of the practice problems that are used to reinforce the key concepts. Users are asked to solve different sets of problems, from the simple questions on time values of money (Figure 5), to Sensitivity Analysis (Figure 6), to Monte Carlo Simulation (Figure 7) and to Supply Demand Equilibrium (Figure 8).

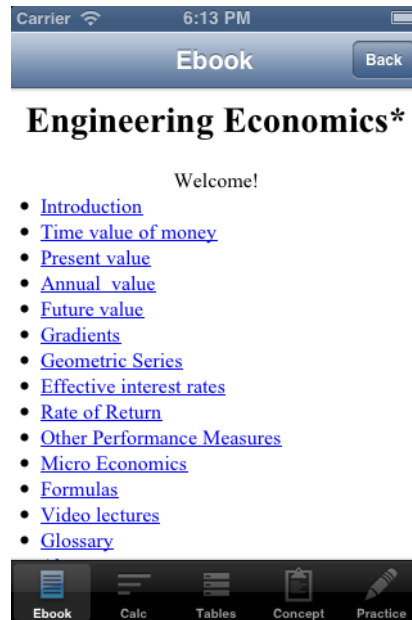


Figure 1. The first tab: Engineering Economics E-Book

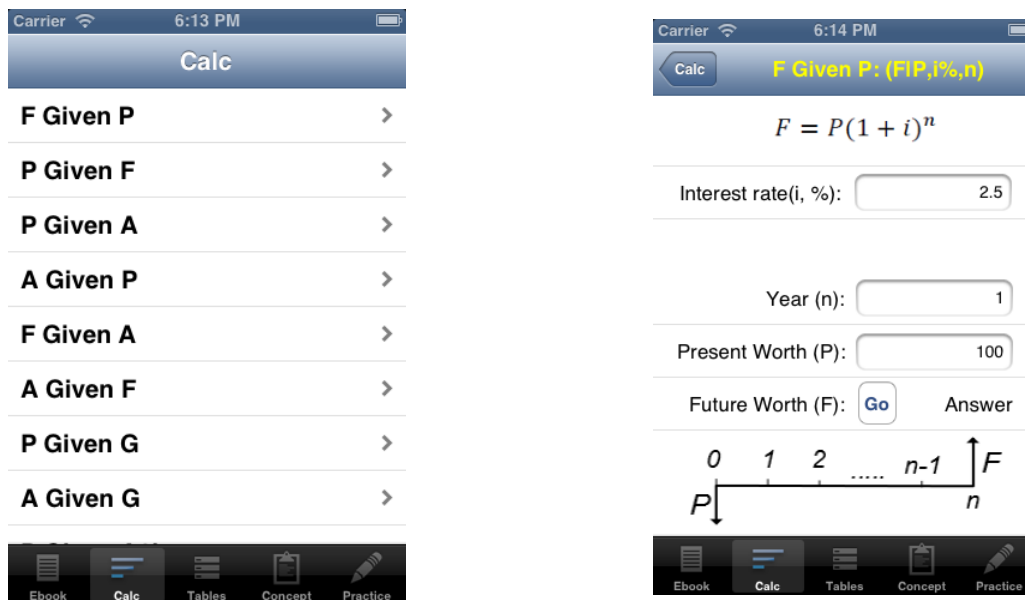
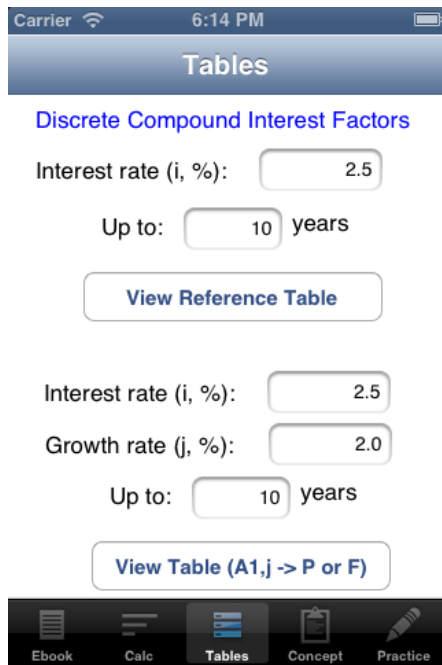


Figure 2. The second tab: Engineering Economics Calculator



Carrier 6:14 PM

Tables F,P P,A F,A PIG,AIG

rate (i): 2.50%

Year (n)	FIP	PIF
1	1.0250	0.9756
2	1.0506	0.9518
3	1.0769	0.9286
4	1.1038	0.9060
5	1.1314	0.8839
6	1.1597	0.8623
7	1.1887	0.8413
8	1.2184	0.8207
9	1.2489	0.8007
10	1.2801	0.7812

Ebook Calc **Tables** Concept Practice

Figure 3. The third tab: Engineering Economics Reference Tables

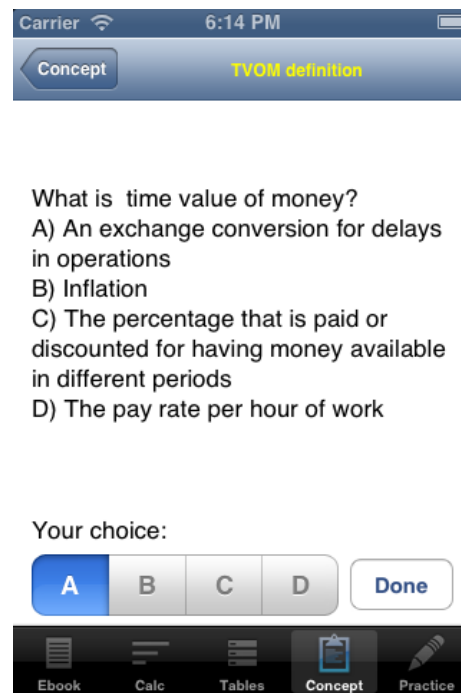
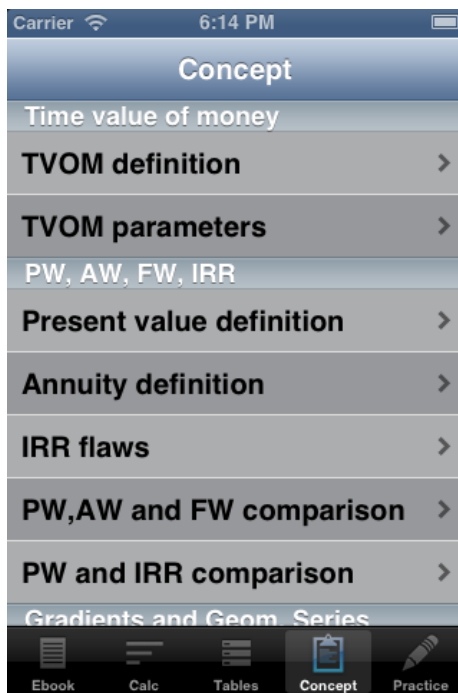


Figure 4. The fourth tab: Engineering Economics conceptual questions

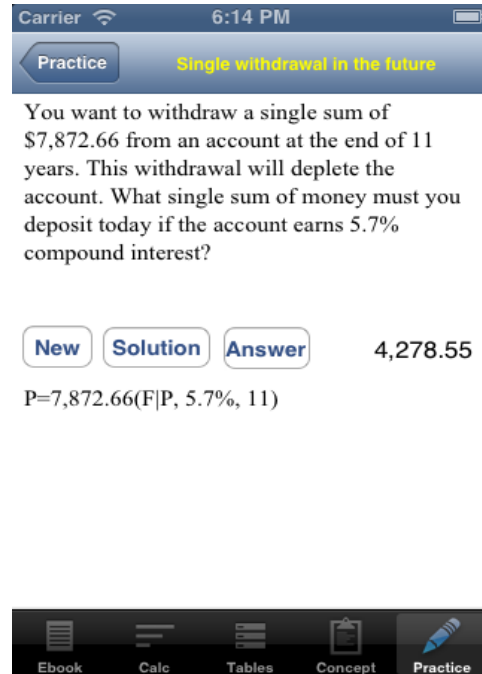
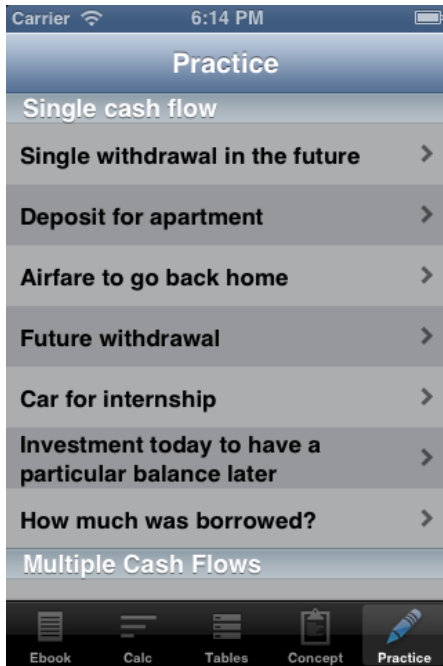


Figure 5. The fifth tab: Engineering Economics practice problems

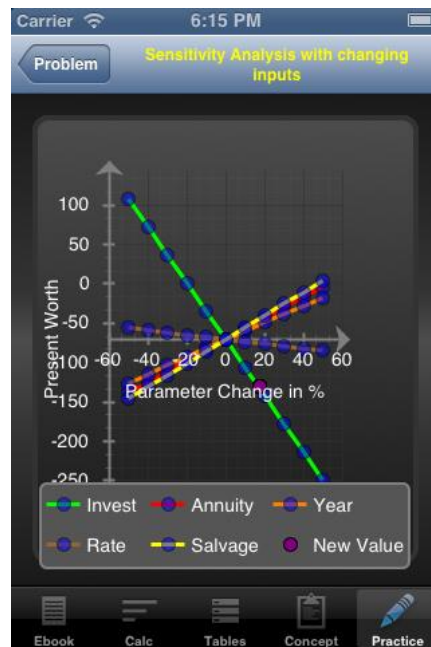
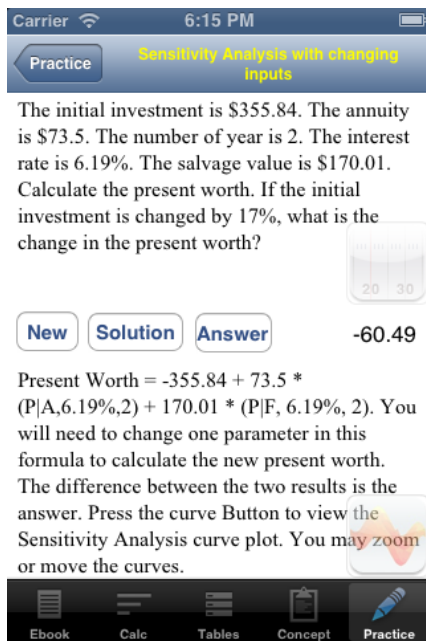


Figure 6. One practice problem: Sensitivity Analysis

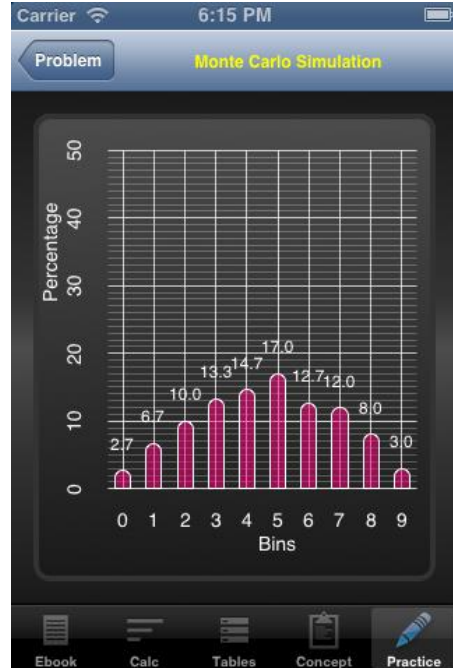
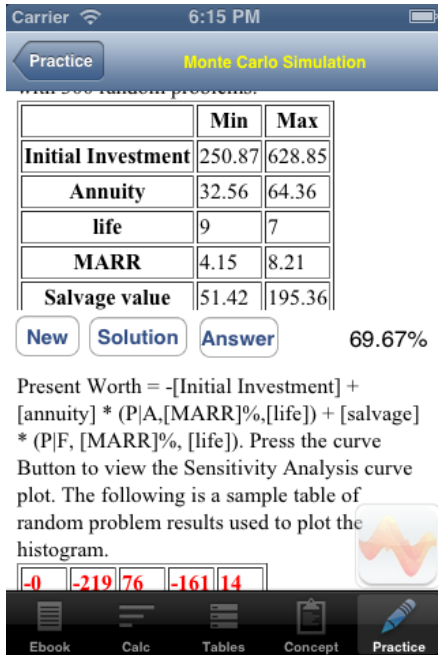


Figure 7. One practice problem: Monte Carlo Simulation

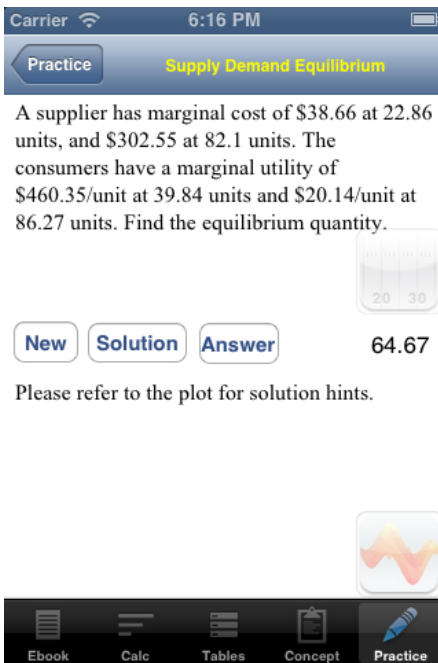


Figure 8. One practice problem: Supplier Demand Equilibrium

The app has been developed for two platforms: Apple iOS and Google Android. The above figures are screenshots for the iOS platform. The interface on the Android platform is similar.

4. Preliminary Assessment Results with Students

To see the effectiveness of our developed mobile application and its implementation in teaching and learning, we have conducted pre and post assessment with the student participants. In pre-assessment, students were asked to share their preference and current use of technology through an online survey. In post-assessment, students' perceived effectiveness of the app and their learning experience with the app were assessed through interviews and an online survey. The pre-assessment was conducted at the beginning of the semester, and the post-assessment was conducted toward the end of the semester.

Student participants. A total of 44 students (53.5% White/Caucasian, 18.6% African American, 20.9% Hispanic, 9.3% Asian/Pacific Islander, 2.3% Native American, and 2.3% other racial backgrounds) who were taking an Engineering Economics course in Fall 2012 participated in this study. A majority of the respondents were male (79.5%), and their mean age was 18 (SD = 3.04; range = 18-29). Their classifications were as follows: 2.3% freshmen, 31.8% sophomores, 38.6% juniors, and 27.3% seniors.

Our pre-assessment results have shown that the majority of students generally enjoyed using technology (86.3% agreed or strongly agreed), and they believed that the use of technology could enhance their learning (84.1% agreed or strongly agreed). However, it is noteworthy that some students (23.3%) have reported that they preferred traditional lectures with no or minimum technology. Another finding is that although many students (81.4%) reported themselves as smartphone owners, students who used their smartphones as learning tools were very rare. The most frequently used functions were texting, making phone calls, and using Internet.

Our post-assessment results have shown that more than half of the students (56.4%) believed that generally the Engineering Economics course was more difficult than other college courses. Regarding the usefulness of our developed mobile app, many students identified areas of the helpfulness of the app in the following order: repeated practice of problems, improving problem solving skills, knowledge comprehension, grasping concept definitions, and knowledge application.

The developed app has been assessed by a small number of students as a pilot study. The distribution was limited to these students through Ad-hoc distribution, that is, it was not available in Apple App store or Google Play yet. Through a number of survey and interviews, besides many bug-fixes, the following general results are summarized:

- 1) It is necessary to link concept questions and practice problems with specific sections in the E-book.
- 2) It is preferred to link concept questions and practice problems with corresponding videos,

since this course is sometimes taught online anyway.

- 3) A gaming or competition style of game app is more attractive to students. This will engage students to the app more closely and frequently.

The pilot study also revealed some hindrance in using the app. For example, some students said that they were technologically challenged, meaning that they were inherently afraid of technology and preferred traditional paper-and-pen style learning. Some students reported that they were only interested in knowing whether the app was useful for the exam, rather than whether they could learn knowledge. For example, if the practice problem was not similar to the exam problem, they reported reduced enthusiasm in using it.

5. Conclusion and Future Work

Overall, students have shown a strong interest in using mobile apps that can assist their learning, and we believe that our findings behoove educators and researchers to develop and utilize smartphone applications because of its great potential to be used as a learning tool. Our study results have shown that students seemed to rely heavily on traditional lectures for their learning. Although students reported that they preferred to learn with technology, they also said that they preferred lectures with no or minimum technology. We believe that further investigation is needed to find out the reasons for the discrepancy.

Regarding the development of a mobile app for an Engineering Economics course, our designed app has implemented many modules to help students reinforce the key concepts and improve their problem-solving skills. The pilot study results provide many valuable inputs that allow continuous improvement of the app. The authors are currently working on a new app with a more engaging game interface. The purpose of the new app is to attract students to maintain their interest and to increase their time of using the app to improve their academic performance. After the new app is fully tested and assessed, it will be made available freely through Apple App store and Google Play.

Reference

1. Ryan, S., Jackman, J., Peters, F., Olafsson, S.: The engineering learning portal for problem solving: experience in a large Engineering Economics class. *The Engineering Economist* 49, 1-19 (2004)
2. Elizandro, D., Matson, J.: Taking a moment to teach Engineering Economics. *The Engineering Economist*

52, 97-116 (2007)

3. Sandberg, J., Barnard, Y.: Deep learning is difficult. *Instructional Science* 25, 15-36
4. Dahm, K., Newell, J.: Baseball Stadium Design: Teaching Engineering Economics and Technical communication in a Multi-Disciplinary. *Journal of SMET Education*, 9-12 (2001)
5. Dahm, K.: Teaching Engineering Economics Using a Web-Based Interactive Simulation. In : The 2003 American Society for Engineering Education annual Conference and Exposition (2003)
6. Mayer, R., ed.: *The Cambridge Handbook of Multimedia Learning*. Cambridge University Press, London (2005)
7. Ben-Zvi, D.: Toward understanding the role of technological tools in statistical learning. *Mathematical Thinking and Learning* 2, 127-155 (2000)
8. Financial Calculators. Available at:
<http://h10010.www1.hp.com/wwpc/us/en/sm/WF04a/215348-215348-64232-20036-215349.html>
9. Instructional software. Available at: <http://maple.dnr.cornell.edu/producs/tvs/index.htm>
10. Blackboard. Available at: <http://www.blackboard.com/>
11. E-book for Engineering Economics. Available at:
<http://www.amazon.com/Concise-Introduction-Engineering-Economics-ebook/dp/B000Q3637K>
12. PhoneGap. Available at: <http://www.phonegap.com/>