

## **"Engineering Economics Jeopardy!" Mobile App Development Process and Student Satisfaction**

**Prof. Weihang Zhu, Lamar University**

Weihang Zhu is an Associate Professor of Industrial Engineering, Lamar University, USA since 2005. He received his Ph.D. in Industrial Engineering from North Carolina State University (2003), USA and his M.S. (2000) and B.S. (1997) in Mechanical and Energy Engineering at Zhejiang University, China. His research interests include Engineering Education, Computer haptics, CAD/CAM, high performance computing, meta-heuristics, multi-axis NC surface machining. He can be reached via email at humorstar@yahoo.com.

**Dr. Alberto Marquez, Lamar University**

**Prof. Julia H. Yoo, Lamar University**

Julia Hyunjeong Yoo is currently an Assistant Professor in the Department of Professional Pedagogy and Program Coordinator of Academic Partnerships Program at Lamar University. Dr. Yoo received her doctorate in Educational Psychology at the University of Texas at Austin. She also earned her M.A. degree in Program Evaluation at the same institution. She is a former elementary school teacher and has given numerous presentations at national, international, and regional conferences.

# **“Engineering Economics Jeopardy!” Mobile App Development Process and Student Satisfaction**

Weihang Zhu<sup>a</sup>, Alberto Marquez<sup>a</sup>, Julia Yoo<sup>b</sup>

<sup>a</sup>Department of Industrial Engineering

<sup>b</sup>Department of Professional Pedagogy

Lamar University, Beaumont, TX, 77706, USA

**Abstract:** This paper presents the mobile application development process and students' satisfaction of the developed app for the Engineering Economics course. The mobile app was first designed in Summer 2012, and the app was incorporated into the Engineering Economics course in two long semesters (Fall 2012 and Spring 2013). The app is named as 'Engineering Economics Jeopardy!' because it was designed in an educational game style, which was one of desired features by students. The app incorporates all the components including E-book, calculator, reference tables, conceptual questions and practical problems, in the previous version but present them in a different and livelier fashion. 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 main interface is a Jeopardy! Game. Through this game, users can compete with two virtual opponents with Artificial Intelligence to answer conceptual questions and practical problems. Different sets of problems range from the simple questions on time values of money to more complex concepts, such as Sensitivity Analysis, Monte Carlo Simulation, and Supply Demand Equilibrium. From the competition interface, users may access the relevant topics in the E-book and use the calculator and interest tables to help themselves. The mobile app has been developed for both Apple iOS and Google Android platforms, and they have been released in the Google Play and Apple App Store. This app is intended to give students more opportunity to learn and practice concepts of Engineering Economics whenever and where they want using their mobile devices. 116 students participated in this study. Surveys and interview results showed that the majority of the students who used the app said that the app aided their learning. 94% of the users said that they would recommend using the app to others who study Engineering Economics.

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## 1. Introduction

Engineering Economics is a core class in the field of engineering and 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 cash flows, costs, and the time value of money through various methods and performance measures. 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. Alternative teaching methods including Internet integration with other courses<sup>1</sup>, and a mechanics analysis of the cash flows<sup>2</sup>, have been proposed in the literature. At the authors' university, the performance for the academic year of 2010 shows that almost 14% of the students dropped the course and the number went up to 43%, if combined with students who failed or obtained a marginal grade D. Consequently, they were required to retake the course according to the university policy. Nationwide, Engineering Economics is a required course by many engineering disciplines. 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 communication channels for interaction with the instructor and amongst classmates; 3) a ubiquitous access to learning materials at their own pace.

Smartphone apps can potentially help today's 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. At the time of our proposal writing in 2010, no suitable apps were available in the stores. Currently there are a few simple apps serving as calculators and interest tables. We have developed an app with a much more comprehensive coverage that allows students to learn most of the Engineering Economics key concepts. In addition, it has been updated through one year's formative assessment with university students.

The rest of the paper is organized as follows. Section 2 introduces research background information. Section 3 explains our published mobile apps, "Engineering Economics Jeopardy!". Section 4 discusses the student satisfaction of the current app. Section 5 concludes the paper and suggests future work.

## 2. Research Background

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. 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 results<sup>3</sup>. To address the difficulties, instructors have been pursuing different teaching aids such as project-based learning<sup>4</sup> and simulation and multimedia to help convey

these concepts<sup>5</sup>. The instructor reports that very frequently students confounded time value of money with inflation.

Since personal computers became available in homes and schools, development in educational technology has progressed at an accelerated pace<sup>6</sup>. In this paper, we focus on mobile apps for multimedia learning. A small application that runs on a smartphone is called an app. Different app development tools are needed for different operating systems (platforms). 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.

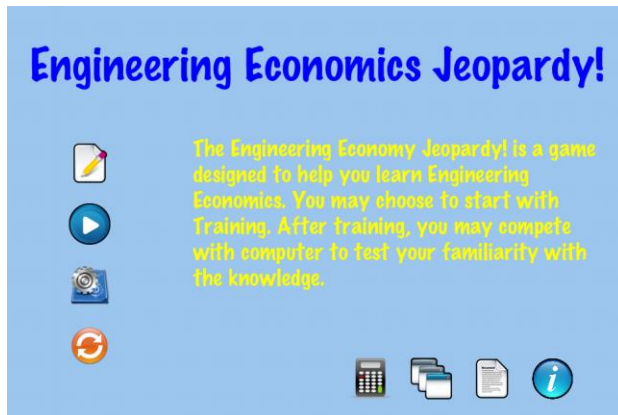
Multimedia is defined as ‘presenting both words (e.g., spoken or printed text) and pictures (e.g., illustrations, photos, animation, or video).’ The theory of multimedia learning suggests that ‘people can learn more deeply from words and pictures than from words alone<sup>7</sup>. Mayer’s cognitive theory 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 followed the instructional design principles derived from the cognitive load theories. Gamification - the use of game thinking and game mechanics in non-game contexts to engage users in solving problems – techniques have been advocated to improve user engagement in a mobile learning environment<sup>8</sup>.

The key research problem that this project is 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.

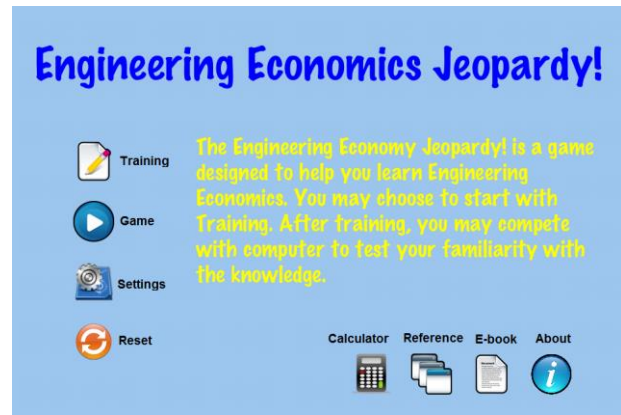
### 3. Development of the Mobile App “Engineering Economics Jeopardy!”

In Summer 2012, 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<sup>9</sup>. The topics include time value of money, cash flow modeling, applications of interest rates, decision making, effects of taxes and depreciation. The user interface was a traditional Android or iOS App with five tabs: E-book, Calculator, Reference Table, Conceptual Problems and Practice Problems<sup>9</sup>. It was incorporated into the Engineering Economics course in two long semesters (Fall 2012 and Spring 2013).

After one year’s formative assessment with undergraduate engineering students, the app was renamed as “Engineering Economics Jeopardy!”. The user interface evolved into an educational game style, which was one of desired features by students (Figure 1). In order to better support different screen resolutions of iPhones and iPads, we adopted a third party graphics library Cocos2d<sup>10</sup>. The app incorporates all the previous components including E-book, calculator, reference tables, conceptual problems and practical problems, from the previous version but present them in a different and livelier fashion. Figure 1(a) shows the main interface. We add hint messages in Figure 1(b) to help explain each icon’s function.



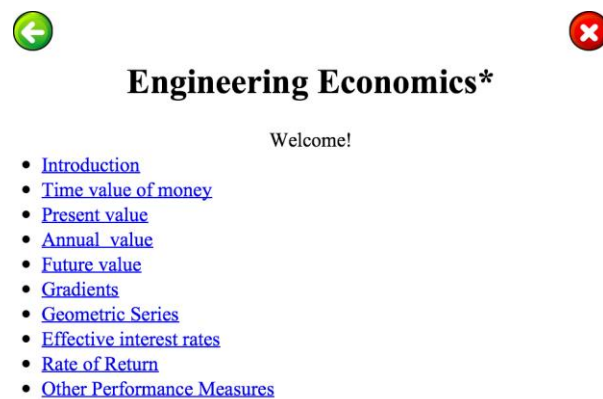
(a) The Main Interface



(b) The Main Interface with Interpretation

**Figure 1.** The Main Interface of “Engineering Economics Jeopardy!”

The E-book is a summary of the key concepts of Engineering Economics (Figure 2). Users may access this E-book from the main interface (Figure 1), or be directed to the relevant topics from a problem (see Figures 7~12).



**Figure 2.** Engineering Economics E-Book

The calculator provides functions to solve basic engineering economics problems with formulas (Figure 3). There formulas are the most frequently used ones in the courses. Users may use them to help them solve more complex problems as part of whole solution procedures. Users may access them directly from the main interface (Figure 1), or from a problem (Figures 7~12).



**Figure 3.** Engineering Economics Calculator

The reference tables allow the users to compute discrete compound interest factors (Figure 4). Users may change the interest rate and years to see different tables as needed in solving their problems.

### Discrete Compound Interest Factors

Interest rate(i, %): 2.5  
Years(n): 10

View Reference Table

Interest rate(i, %): 2.5  
Growth rate(j, %): 2.0  
Years(n): 10

View Table (A1,j -> P or F)

rate (i): 2.50%

F,P; P,A    F,A; PIG, AIG

Year (n)	FIP	PIF	PIA	AIP
1	1.0250	0.9756	0.9756	1.0250
2	1.0506	0.9518	1.9274	0.9188
3	1.0769	0.9286	2.8560	0.8501
4	1.1038	0.9060	3.7620	0.7858
5	1.1314	0.8839	4.6458	0.7252
6	1.1597	0.8623	5.5081	0.6681
7	1.1887	0.8413	6.3494	0.6143
8	1.2184	0.8207	7.1701	0.5635
9	1.2489	0.8007	7.9709	0.5155
10	1.2801	0.7812	8.7521	0.4701

**Figure 4.** Engineering Economics Reference Tables

The main game interface is a Jeopardy! Game. Through this game, users can compete with two virtual opponents with Artificial Intelligence to answer conceptual questions and practical problems (Figure 5). Before users attempt the game, they may try with training sessions first (Figure 6). The training has the similar problems and setup as in the game but users are not under timer pressure, because users are allowed to continue to work on the problem even if timer expires. The training has three rounds. Each round has 10 conceptual problems and 20 practical problems. The problems in the training are similar to the real game but the options sequence and question parameters are randomized. So each time users will see different questions.

Round 1:

Alberto: 0

Julia: 0

: 0

. your turn.

	1	2	3	4	5
\$100	\$100	\$100	\$100	\$100	\$100
\$200	\$200	\$200	\$200	\$200	\$200
\$300	\$300	\$300	\$300	\$300	\$300
\$400	\$400	\$400	\$400	\$400	\$400
\$500	\$500	\$500	\$500	\$500	\$500
\$600	\$600	\$600	\$600	\$600	\$600

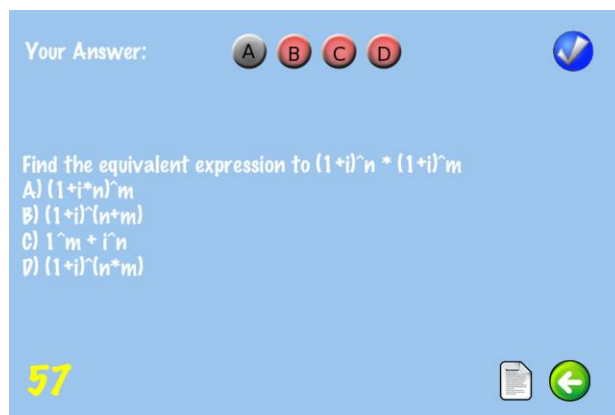
**Figure 5.** “Engineering Economics Jeopardy!” Game Competition Interface



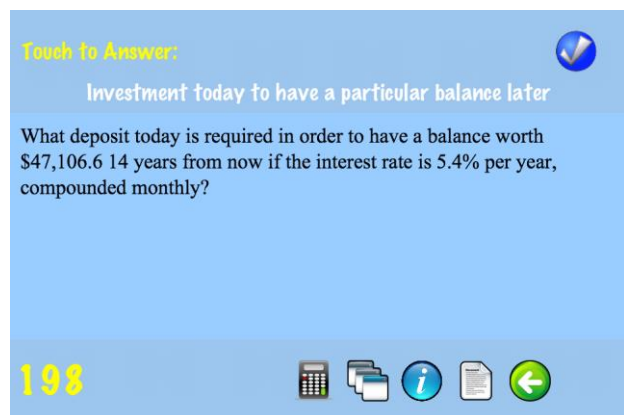
**Figure 6.** Game Training Interface

Conceptual problems will check the users' understanding of fundamental concepts in Engineering Economics, starting from the basic algebra equations to more advanced concepts (Figure 7).

Different sets of practical problems range from the simple questions on time value of money (Figure 8) to more complex concepts, such as Sensitivity Analysis (Figure 9), Project Alternatives (Figure 10), Monte Carlo Simulation (Figure 11) for risk assessment, and Supply Demand Equilibrium (Figure 12). These complex problems are accompanied with graphs. From the competition interface, users may access the relevant topics in the E-book and use the calculator and interest tables to help themselves. After repeated training, users are expected to get more familiar with relevant topics and solution procedures.



**Figure 7.** Conceptual Problem Interface



**Figure 8.** Example: Time Values of Money

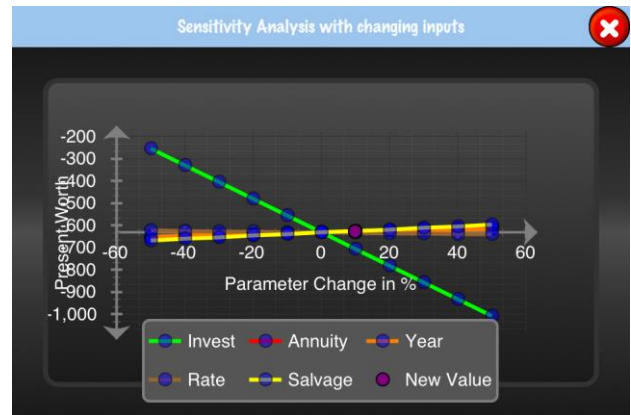


**Touch to Answer:**

**Sensitivity Analysis with changing inputs**

The initial investment is \$752.7. The annuity is \$27.8. The number of year is 2. The interest rate is 8.57%. The salvage value is \$83.7. Calculate the present worth. If the annuity is changed by 10%, what is the change in the present worth?

**298**



**Figure 9.** Example: Sensitivity Analysis

**Touch to Answer:**

**Feasible alternatives with financial constraints**

Below you will find a table with the information about project alternatives. Please find the optimal decision based on maximum present value.

Project	A	B	C	D	E
Initial Investment (\$)	292	695	525	692	337
Present value (\$)	259	206	794	264	367

**292**

**Figure 10.** Example: Project Alternatives

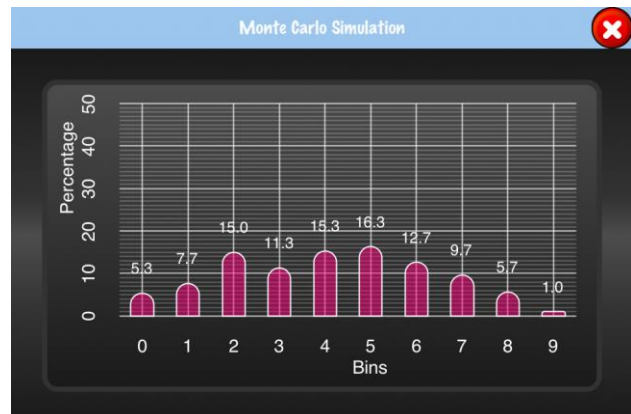
**Touch to Answer:**

**Monte Carlo Simulation**

The initial investment is between \$224.29 and \$741.98. The annuity is between \$31.26 and \$68.88. The life is between 11 and 5 years. The MARR interest rate is between 4.5% and 8.1%. The salvage value is between \$61.76 and \$190.35. Run a Monte Carlo Simulation with 300 random problems.

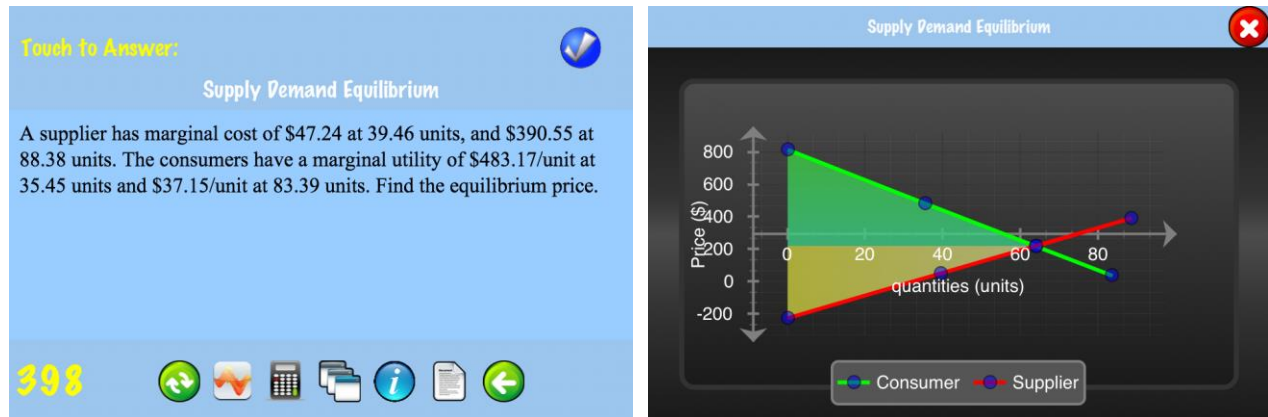
	Min	Max
Initial Investment	224.29	741.98
Annuity	31.26	68.88

**98**



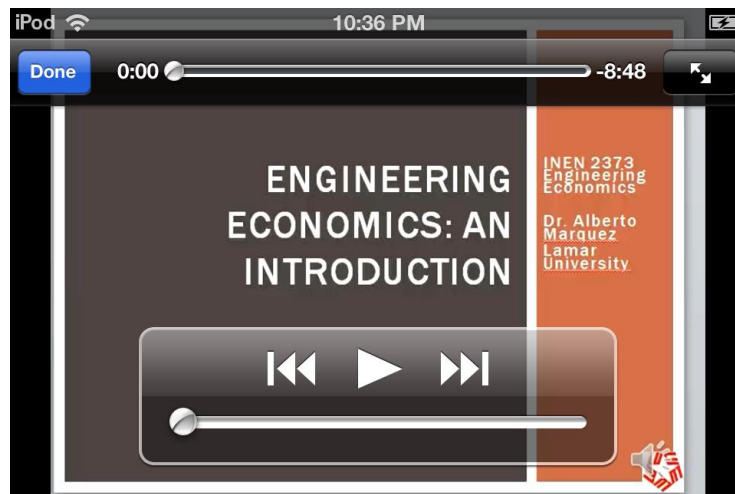
**Figure 11.** Example: Monte Carlo Simulation for Risk Assessment





**Figure 12.** Example: Supply Demand Equilibrium

Students have access to more than forty videos produced for delivery of an online course (Figure 13). While most of the topics are covered, more videos are still in production to solve sample problems or cover more detail material as we see fit according to the students' feedback. Each video is about 10 minutes long, on specific topics, and is close captioned. The videos are uploaded to a private video streaming service that is paid by the University. With the data and video playing capabilities of smart phones, students have the possibility of not only practicing problems or reading a text book, but also being engaged as class attendants in an asynchronous lecture at their convenience. We constantly receive good review due to the fact the videos are short and to the point, reducing the distractions that students typically have when learning from long video lectures.



**Figure 13.** Example: Video Lectures Delivered through the E-book Links

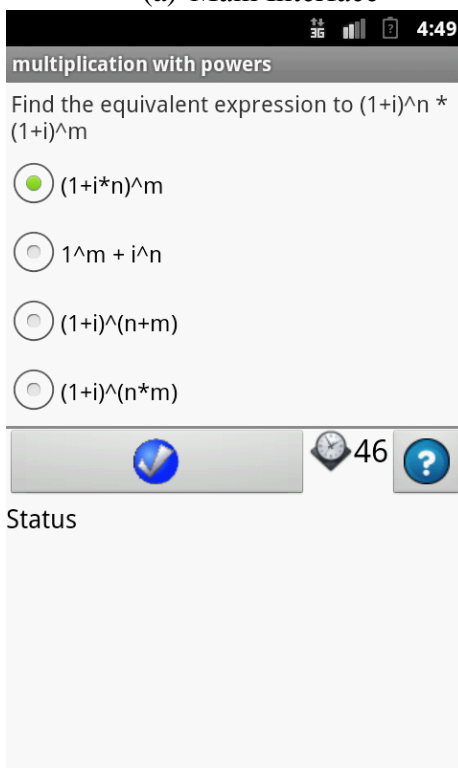
The mobile app has been developed for both Apple iOS and Google Android platforms, and they have been released in the Google Play and Apple App Store. The two app implementations are different but the contents are essentially the same. The above narration referred to the iOS app version. The following figures illustrate a few screenshots of the Android app version (Figure 14). The apps have been released in the Google Play and Apple App Store for free download. The app name is 'Engineering Economics Jeopardy!'.



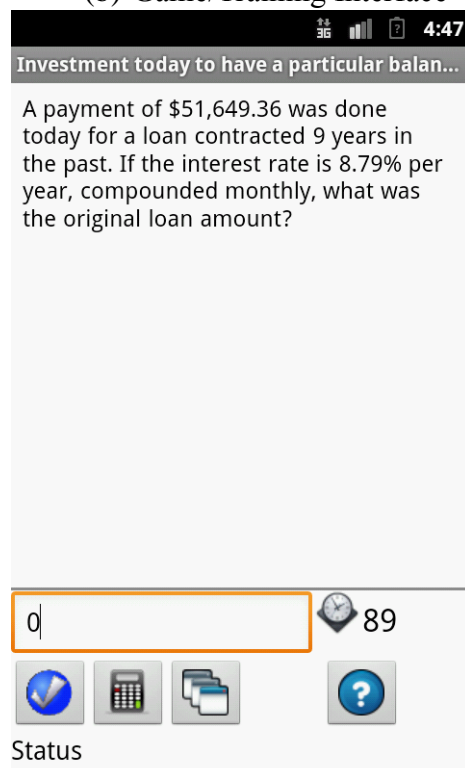
(a) Main Interface



(b) Game/Training Interface



(c) Conceptual Problems



(d) Practical Problems

**Figure 14.** Android Version of “Engineering Economics Jeopardy!”

#### 4. Student Satisfaction Assessment Results

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 online surveys. In post-assessment, students' perceived effectiveness of the app and their learning experience with the app were assessed through interviews and online surveys. The pre-assessment was conducted at the beginning of the semester, and the post-assessment was conducted toward the end of the semester.

A total of 116 students (59.4% White/Caucasian, 16.4% African American, 13.8% Hispanic, 8.6% Asian/Pacific Islander, .9% Native American, 0.9 % other racial backgrounds) who were enrolled in Engineering Economics course participated in the study for extra course credit. A majority of the respondents were male (79.3%). Participants included 5 freshmen, 30 sophomores, 52 juniors, and 31 seniors, and their mean age was 23.2 (SD = 3.7; range 18-34). Almost half of the students (51.7%) indicated that they were employed, and 31% of them specified that their work was not academically relevant at all.

Many (87%) students indicated that they had their own smartphones. Regarding their use and preference of technology in their learning, the majority of students (90.5%) said that they enjoyed using technology, and 82.7% of them believed use of technology could enhance their learning. More than half of the students (62.9%) also indicated that an instructor's use of technology in teaching could help them learn better. However, 30.2% of students specifically indicated that they preferred a traditional lecture format with no or minimum technology for their classroom learning.

Regarding the developed smartphone application, students seemed to like the idea of utilizing their readily available tool for their learning. Below is an interview snippet from one student who expressed enthusiasm about using the app:

“It's kind of cool! Being able to have something else that helps me because I use my phone every single day. With the app, I could just be about anywhere to study. Say, if I have a break time at work, I just sit there and just pull out the app and see if I could do anything else instead of just sitting there.”

Of the smartphone app users, 63% students reported that the use of the app was helpful for their learning. It is noteworthy that student satisfaction of the app went up from the first semester (46.43%) to the second semester (80.56%) of this research project. In fact, 35% of the app user in the first semester said that they would recommend using the app to others who take the Engineering Economics course, and the percent went up to 94% in the second semester. In the first semester, the students used the first version of the app. In the second semester, the app has been updated to 'Engineering Economics Jeopardy!' We attribute the positive change of student experience to this app upgrade. Across two semesters, students reported that repeated practice of problems and problem solving skills as two most helpful features of the app.

#### 5. Discussion and Conclusion

Our study findings show that students are very enthusiastic about using their smartphone as their learning tool, and generally students find their smartphone app helpful for their learning, especially in Engineering Economics course. Considering the exponentially growing smartphone users among students, adopting smartphone apps into teaching seems like a timely step for college instructors, especially for those who teach subject areas that students typically struggle with. Yet, many students reported that up until this time, they never encountered instructors who used a smartphone app for course lessons. As with any innovative approaches, effectively incorporating smartphone apps into teaching is not an easy task. Our study findings showed that when students did not see clear benefit of using the app, they just stopped using it. For example, if using the app does not lead to their higher course grades, students quickly lose interest in using the app.

Students were interested in using the app to solve problems during the in-class activities. Some students preferred using the app for computing the compound factors and generating tables. Upon students' requests, the course instructor permitted students to use the app during exams. Complex exams keep students solving the exam, instead of seeking external help during the test time through the mobile network. The easily accessible nature of the app, which only requires a click of a button, seemed to attract a higher number of students to pull out relevant materials with ease as appose to traditional textbooks or course materials. The students feel invigorated now that higher grades are within reach if they spend more time in practicing with the app. In addition to using the app as a readily available resource for individual study, students also seemed to find the app useful for in-class discussions, peer to peer review of problems and peer tutoring.

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. Regarding the development of a mobile app for an Engineering Economics course, our improved app has reflected the feedback from the student users and implemented many modules to help students reinforce the key concepts and improve their problem-solving skills. The app has been made available freely through Apple App store and Google Play. We will continue to pursue formative assessment and improvement during the NSF grant period.

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