AC 2007-1653: AN ONLINE REAL-TIME QUIZ SYSTEM FOR READINESS ASSESSMENT TESTING

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Introduction

Readiness assessment tests (RATs) are a simplified formative assessment tool to evaluate the incremental progress of individual learners in a classroom environment. Often times, a RAT is administered to measure the understanding of one or two general concepts from prior course material; it is also used to estimate the preparedness of each learner to move forward with new material in the current course lecture. As a means of individual formative assessment, RATs have shown promise as a feedback tool for learners within a variety of classroom environments.

RAT usage in the classroom was first proposed and investigated by Michaelson et al., who were evaluating individual learning in large courses within a business-related curricula[1]. Adaptation of the RAT concept within engineering education occurred later, most likely in the early 1990s, where it provided a modern placement of the traditional unannounced quiz into engineering education pedagogy. Since that time, engineering education researchers have shown the effectiveness that RATs may have on learner performance and, more importantly, improved learner understanding of the course material[2].

Because RATs are usually paper-based and therefore require grading, the instructor cannot immediately adjust his/her content to the learners' preparedness, even when classroom discussion is used to evaluate learner understanding. To mitigate this problem, researchers have developed near real-time feedback techniques for RAT scoring. Yost et al. solicited responses to RAT questions on scantron forms and then used a portable scantron reading device in the classroom for grading[2]. Other researchers have begun to utilize online course management systems such as BlackBoard and WebCT for RAT scoring and other course assessments[3,4,5].

In each of the cases above, the RAT feedback results must typically be manipulated to have any type of immediate pedagogical value to both the instructor and the learners. Therefore, to transform the RAT concept into a real-time formative assessment tool, an online real-time quiz system was developed. The real-time quiz system administers the RAT electronically but also provides real-time feedback to the instructor both numerically and graphically in the classroom. Graphical results of the real-time quiz can be used immediately by the instructor to create 'teachable moments' that may better facilitate learner understanding of the course material.

Research Objectives

This paper presents the development and implementation of an online real-time quiz system to enhance learner understanding within a large, two-semester freshman engineering course sequence at Texas A&M University. The research objectives for this study can be categorized into two separate domains: technology and instruction.

Several web-based technologies currently exist that may be used to develop an online real-time quiz system. Among these technologies are: web databases, dynamic web pages, and real-

time graphing software. However useful these individual components may be though, the problem that most end users typically arrive at for instructional purposes is: how are these different components best combined to produce the desired instructional technology? In this research effort, we address the following two questions:

(1) What is the optimal way to assemble current web-based technologies for an online real-time quiz system? An optimal system design will include the least amount of objects possible that are also interchangeable.

(2) What is the minimum financial cost associated with assembling the technologies in the optimal manner? The online real-time quiz system should ideally consist of components that are freely-available.

The instructional goals for this research are straightforward. In this investigation, we attempt to answer the following two research questions related to instruction:

(1) Does the use of the real-time quiz system developed enhance learner understanding of the material presented? Higher exam scores may indicate a deeper understanding of the course material for learners who used the system versus learners who did not.

(2) What, if any, are the negative impacts that may occur by using an online real-time quiz system? Abandoning the traditional paper and pencil format may cause the learners to focus more on the technology instead of on the material.

The following sections outline the framework for the real-time quiz system, the application and preliminary results that have been obtained, some conclusions based on these results, and a description of the work that will continue to be pursued.

Real-Time Quiz System Design

The main technical purpose of the online real-time quiz system is to effectively deliver the assessment content to learners, and for the instructor to easily retrieve the results in real-time. Multiple self-contained technologies exist that were considered. Among these were the Microsoft SQL Server and its desktop database counterpart, Microsoft Access, along with the Oracle database system. While these are powerful information systems, fully capable of being customized to accomplish the tasks involved, these products do possess generally higher costs, limitations on platform availability, and they also typically require special knowledge and/or training for setup, use, and maintenance.

Our final solution involved the assemblage of publicly-available software with documentation readily available on the Internet. The components used were: a MySQL database located on a server, a front-end web interface that used dynamic PHP (Hypertext Preprocessor) code, and a second front-end web interface using PHP and JavaScript for graphical results. Figure 1 illustrates the general component configuration and flow of information within the system:
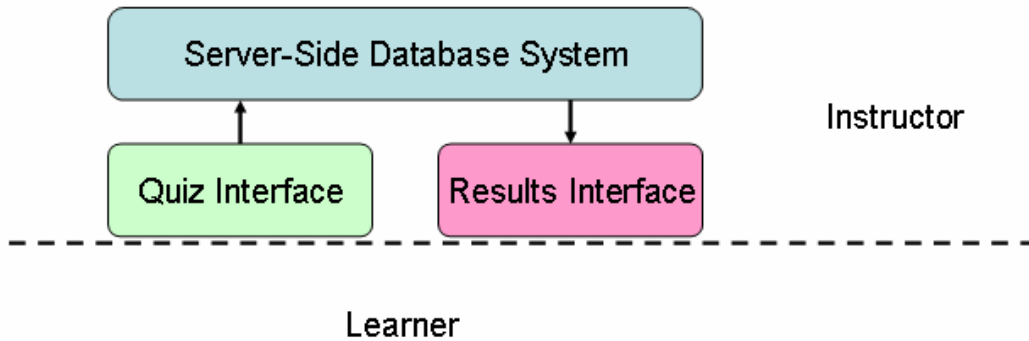
Figure 1. Component configuration and flow of information within the system.

The server-side database selected was the MySQL application. MySQL is a powerful open source database product that has been available for many years[6]. The MySQL application runs on platforms likely to be encountered in an academic setting (i.e. Windows, Mac OS, and Linux), and the community version of the database is available free of charge. In our real-time quiz system, a single database was created for the class. Within the database, a separate table was created for each real-time quiz that was administered. Typically, each real-time quiz consisted of one or more multiple choice questions; therefore, only a primary numbering key, a unique identification number for the learner, and one or more fields for answer selections, were required as fields.

Management of the MySQL database was initially accomplished by using the phpMyAdmin program[7]. phpMyAdmin is a freely-available HTML-based program that allows the user to interface with the MySQL database with little effort to create databases, tables, edit fields and records, etc. Later development of our system resulted in the creation and implementation of PHP scripts that accomplished these manual tasks automatically and in a more customized manner. It should be noted that most databases available today could be used instead of the MySQL database, assuming that a web-based programming language can interact with the database. Figure 2 presents a screenshot of the phpMyAdmin web interface for the MySQL database being used to record learner responses to a real-time quiz (ID numbers obscured for privacy).
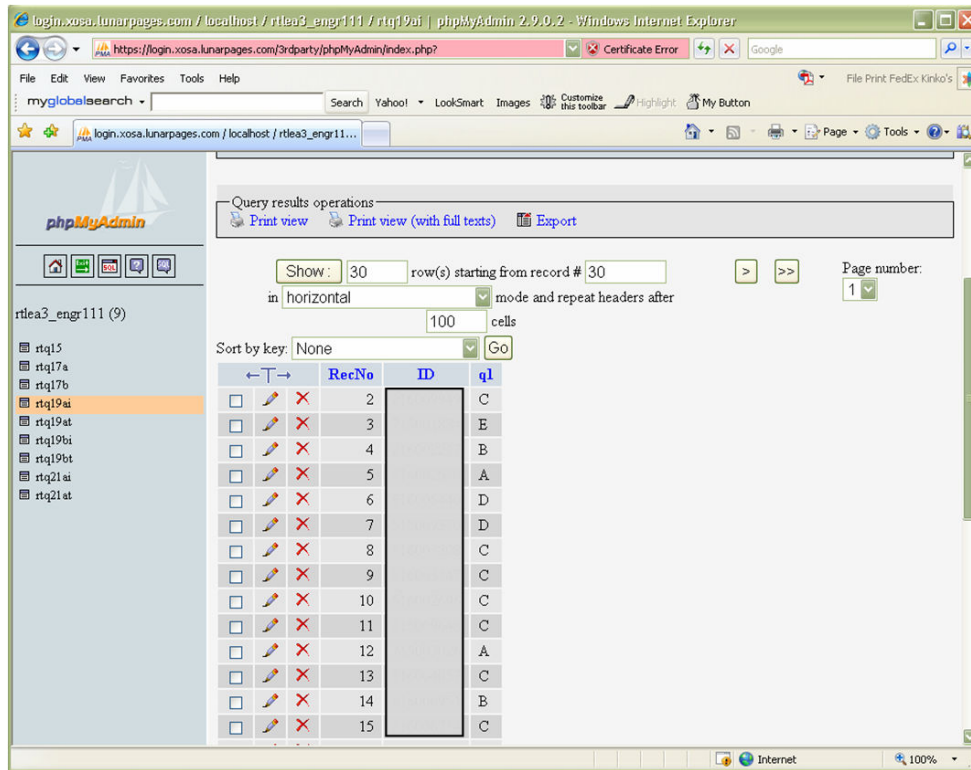
Figure 2. MySQL screenshot with results of a real-time quiz.

As with the database programming interface, several programming languages could have been selected for the dynamic web-based interface. Among these are: C, C++, Java, and Perl. We selected the PHP language due to its ease of use and widespread documentation on the Internet and in reference books (often coupled with MySQL program). PHP is also available free of charge and it can be used on any platform. When an instructor wants to create a new real-time quiz, he or she initially designs the quiz graphics in Microsoft PowerPoint (or another type of presentation or drawing software). Figure 3 provides an example of a quiz being designed for administration during this study.

Once the graphical components of quiz are designed, the slide layout is exported as an image file, typically in .jpeg format. The instructor then enters the real-time quiz system administration page and chooses to begin a new quiz. The image file is uploaded by the instructor to the server using a PHP script. A sequence of questions is then answered by the instructor. These include: (1) how many answer responses are on the quiz, and (2) which is the correct answer. Once these questions are answered, a new real-time quiz is automatically created. The instructor can then choose to make the website link for the real-time quiz active and the learners are able to log on to the course website and take the assessment. Figure 4 illustrates an example of online real-time quiz created using the information in Figure 3.

During and after the real-time quiz is administered, the instructor can view the results. The graphical results interface selected for our system was a commercial product obtained from the jPowered company[8]. We decided to use this component from jPowered because it required the least amount of modifications script-wise, to produce the desired result. Although there were

many different software choices to consider for the results interface, all of the products we encountered (that could accomplish the necessary task) were at least some form of shareware. The cost for the jPowered graphing software was around $50 with unlimited usage as part of the license agreement. Although there was a one-time cost involved, we can now create an unlimited number of real-time quizzes through our current system setup. Figure 5 presents the results from the administration of the real-time quiz shown in Figure 4. The actual application procedures and preliminary results from the real-time quiz system are outlined in the following section.

Figure 3. PowerPoint slide created for a real-time quiz.

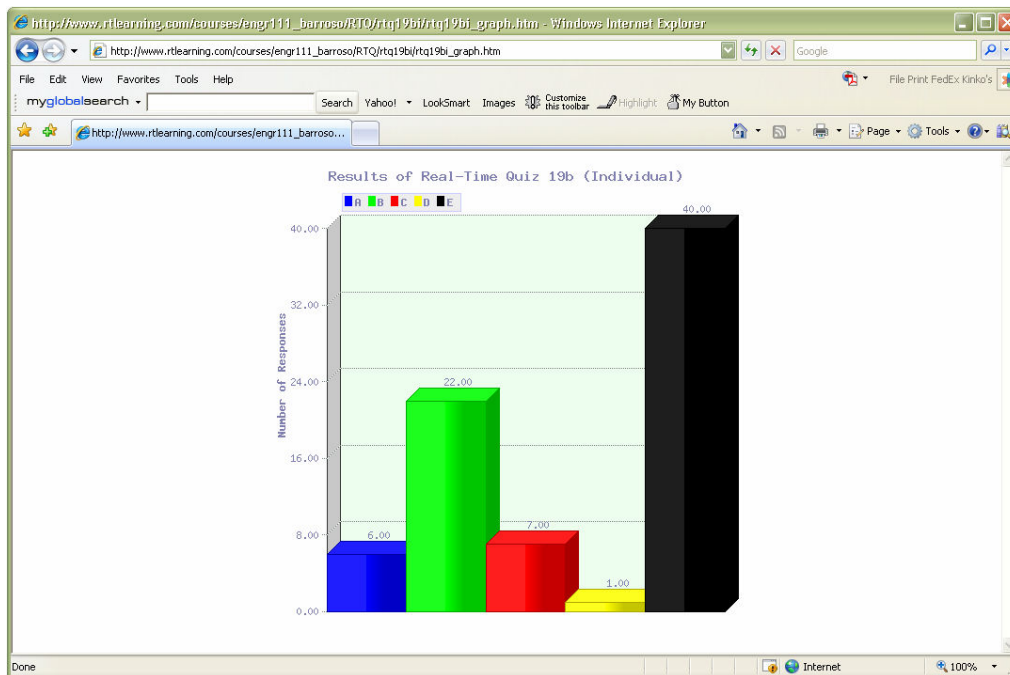Figure 4. Administration of a real-time quiz.

Figure 5. Graphical results of a real-time quiz being administered.

Application and Preliminary Results

The real-time quiz system was implemented in a large, two-semester freshman engineering course sequence at Texas A&M University. Catalog descriptions of the two courses are[9]:

Engineering 111. Foundations of Engineering I: Introduction to the engineering profession, ethics, and disciplines; development of skills in teamwork, problem solving and design; other topics included, depending on the major, are: emphasis on computer applications and programming; visualization and CAD tools; introduction to electrical circuits, semiconductor devices, digital logic, communications and their application in systems; Newton's laws, unit conversions, statistics, computers, Excel; basic graphics skills; visualization and orthographic drawings.

Engineering 112. Foundations of Engineering II: Continuation of ENGR 111. Topics include, depending on the major: emphasis on computer applications and programming and solids modeling using CAD tools or other software; fundamentals of engineering science; advanced graphic skills.

Both courses require first-year engineering calculus as at least a co-requisite and all freshman engineering majors at Texas A&M University are required to take these two courses.

The average number of learners enrolled in a single lecture of each course is approximately 100. Our investigation for the Engineering 111 course consisted of using one lecture group as the experiment (n = 75) and a separate lecture group (n = 83) as the control. The actual content for each real-time quiz was determined by the two course instructors and was based on the materials used across all sections of the course. Because this course sequence requires the use of 'teaming' among the learners as part of the instruction process, we incorporated this into the real-time quiz framework. Initially, each learner would take the quiz individually at their own computer workstation. The instructor would monitor the results on a separate screen, not visible to the learners. Once the allotted quiz time had elapsed (which typically ranged from 5- to 10-minutes) the learners would break into their assigned teams. The teams were assigned by the instructor at the beginning of the semester and were usually based on declared major. Team sizes ranged from three to four learners, with four being the maximum. After forming into the teams, the learners were tasked with discussing the real-time quiz question(s) being asked and were to arrive at a team answer. Each team would then submit a second real-time quiz collective response using a separate team interface that was identical to the individual real-time quiz. Once the team choice was submitted, learners were shown the graphical results of both the individual and the team responses. Additional discussion occurred if results were split.

To determine whether or not the use of the real-time quiz system was effective on the understanding of the material by the Engineering 111 learners, we evaluated raw exam scores for three exams between the two different sections. The exams administered to the learners were common exams, with questions being determined by a committee of instructors for the course; therefore all learners enrolled in Engineering 111 (and 112) take the identical exam. Figures 6, 7, 8 present the distribution of grades between the experimental and control lectures for Exams 1, 2, 3, respectively, for Engineering 111.
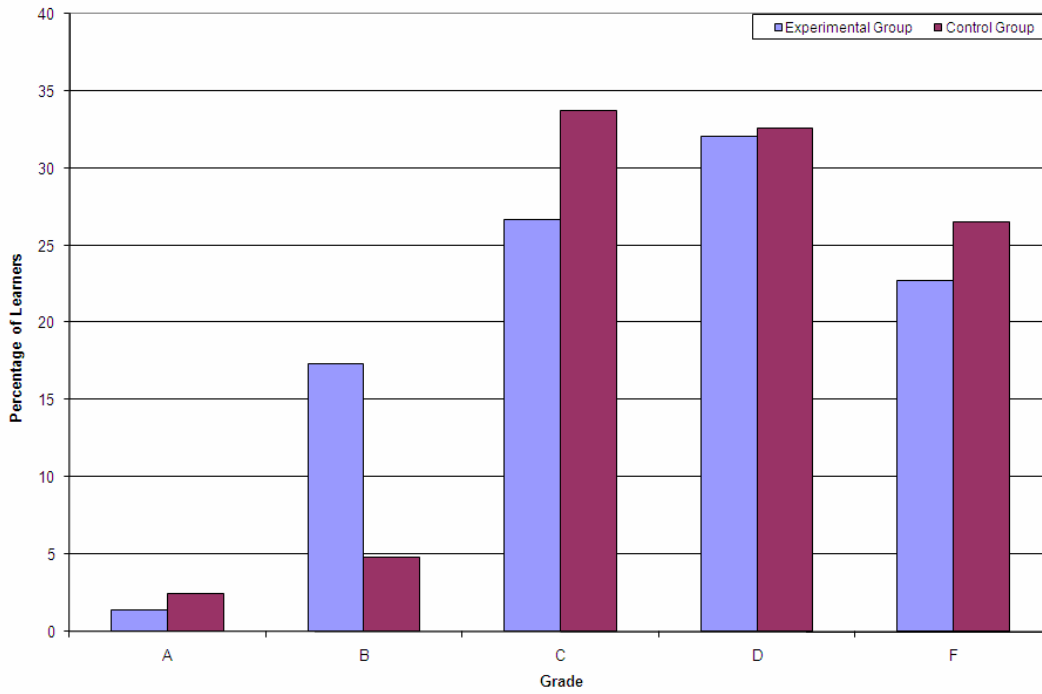
Figure 6. Grade distribution results from Engineering 111 Exam 1.
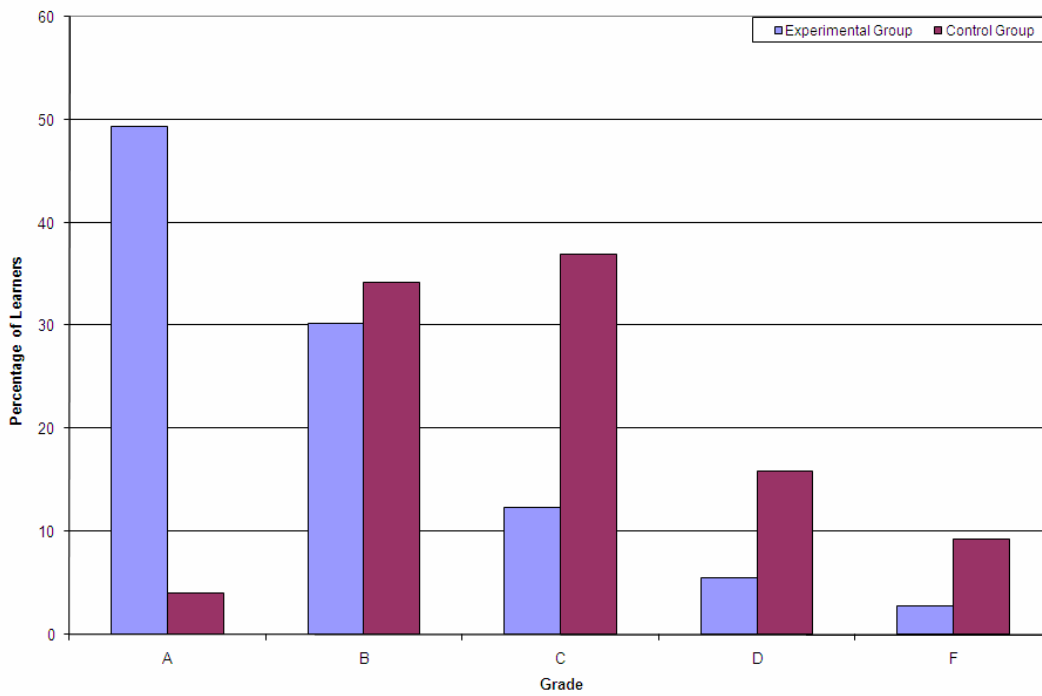

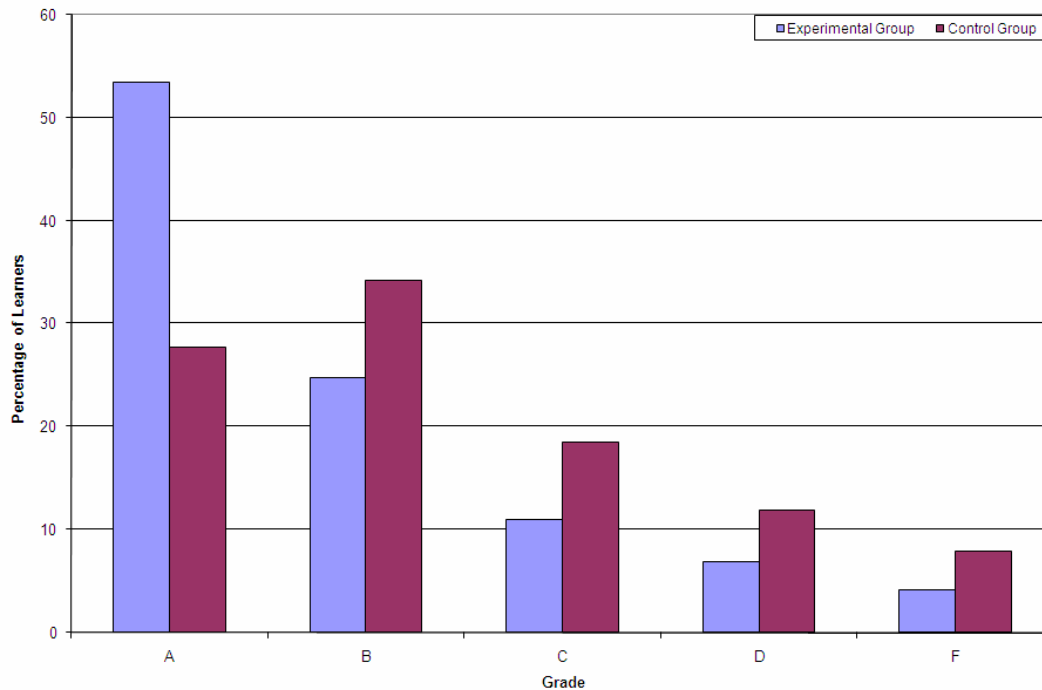Figure 7. Grade distribution results from Engineering 111 Exam 2.

Figure 6. Grade distribution results from Engineering 111 Exam 3.

Table 1 provides the descriptive statistics for the experimental and control groups across the three exams for the Engineering 111 course.

Table 1. Descriptive statistics for the Engineering 111 exam results.

Component	Experimental Group Exam 1	Experimental Group Exam 2	Experimental Group Exam 3	Control Group Exam 1	Control Group Exam 2	Control Group Exam 3
Mean	66.9	87.1	89.0	66.8	74.7	80.5
Std Dev	13.1	18.2	15.6	11.0	11.7	14.4
Median	68.0	89.3	91.0	68.0	76.5	82.0
Max	93.0	100.0	113.0	95.0	97.0	108.0
Min	24.0	42.9	35.0	32.0	25.0	31.0

What can be seen from the numerical results is that the learners in the experimental group scored higher, on average, on Exams 2 and 3 than did the control group. Exam 1 produced similar scores but the significant part of that result is that the learners were not actively participating in the real-time quiz system (to a great extent) prior to Exam 1; most of the quizzes were the standard paper-based assessment.

As of the final submission of this paper, we do not yet have the complete exam results for the implementation of the real-time quiz system in the Engineering 112 course. However, we will be presenting this data at the conference. Results for the Engineering 112 course, and the course we have already evaluated, will be posted at the following website: http://www.rtlearning.com/ASEEpaper2007.

Conclusions and Future Work

This research has been the preliminary investigation on the effectiveness of an online real-time quiz system developed primarily for a large freshman engineering course sequence at Texas A&M University. Through continued refinement, the real-time quiz system has progressed into an easy to use tool for an instructor to evaluate learner performance in an immediate fashion when classroom contact is occurring. Implementation of this system has shown that on average, learners may perform better on exams than their peers who study the identical material, yet do not utilize the real-time quiz system. Even if causation is excluded, the individual and teaming experiences gained by the learners through the use of the real-time quiz system would most likely serve as some benefit for self-evaluation in the course.

We are currently evaluating the effectiveness of the real-time quiz system using a similar experimental and control group during the Spring semester 2007 in the Engineering 112 course. We also intend to conduct a usability study to determine what the best format is to administer questions (e.g. fill in the blank versus multiple choice). If our results continue to show promise, we may be able to extend this experiment across additional sections of the Engineering 111/112 course sequence, as well as other courses at Texas A&M University or at other universities.

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