
AC 2012-4861: USING ONLINE QUIZZES AND DISCUSSION FORUMS TO ENHANCE LEARNING NUMERICAL METHODS

Dr. Bipin K. Pai, Purdue University, Calumet

Bipin K. Pai has a B.S., aeronautical engineering, Indian Institute of Technology, Madras, India, 1972; a M.S., mechanical engineering, University of Rochester, 1973; and a Ph.D., mechanical engineering, University of Rochester, 1978. He was Purdue University, Calumet, Director of Honors Program, 2005-present; Purdue University, Calumet, professor of mechanical engineering, 1991-present, full-time; Purdue University, Calumet, Associate Professor of mechanical engineering, 1984-1991, full-time; and Purdue University, Calumet, Assistant Professor of mechanical engineering, 1979-1984, full-time. He was also Faculty Fellow at Argonne National Laboratory, to work on finite element analysis of polycrystalline arrays to determine grain boundary mechanics, Summer 1985; Faculty Fellow at Argonne National Laboratory, to work on finite element analysis of shipping casks in edge-drop impact tests, Summer 1987; and Faculty Fellow at Argonne National Laboratory, to work on finite element stress analysis of solid breeder blanket of tokamak fusion reactors – ITER (International Thermo-Nuclear Experimental Reactor) Program, Summer 1988. He won the Faculty Research Leave Award (Sabbatical Leave) at Argonne National Laboratory, to work on finite element stress analysis of Tokamak fusion reactor first walls, 1986-1987; and the United States Air Force Summer Faculty Research Award, Edwards Air Force Base, California, to work on experimental and theoretical analysis of the fracture behavior of a composite solid rocket propellant, Summer 1989. He holds current membership in professional organizations the American Society of Mechanical Engineers and the American Society for Engineering Education. He has been awarded travel grants to present a research paper at the Fourth International Congress of Biorheology, Jikei University, Tokyo, Japan; expenses covered in part by an invited lecture travel grant from the International Congress of Biorheology and in part by a Purdue XL International Travel Grant, 1981; the Summer Faculty Research Award at Argonne National Laboratory, to work on finite element analysis of polycrystalline arrays to determine grain boundary mechanics, 1985; the Faculty Research Leave Award (Sabbatical Leave) at Argonne National Laboratory, to work on finite element stress analysis of Tokamak fusion reactor first walls, 1986-1987; the Summer Faculty Research Award at Argonne National Laboratory, to work on finite shipping casks in edge-drop impact tests, 1987; and the Summer Faculty Research Award at Argonne National Laboratory, to work on finite element stress analysis of solid breeder blanket of tokamak fusion reactors – ITER (International Thermo-Nuclear Experimental Reactor) Program, 1986. His service activities (within and outside of the institution) include Department, 2000-present, Engineering Assessment Committee, 1984-present, multiple faculty search committees, 1995-present, Mechanical Engineering Coordinator School, 2007-2009, Strategic Plan Committee, 2005-present, Curriculum Committee, 2008-present, Chair, EMS Committee on Outstanding Undergraduate Student Award Committee University, 2009-2011, University Committee on Promotions and Tenure (Panel C), 2005-present, Director of the Honors Program, 2008-2010, University Senate, 2010-present, AQIP Committee Professional, 2000-present, ABET, Mechanical Engineering Evaluator. The most important publications and presentations from the past five years: Bipin Pai and Pattabhi Sitaram, "Elastic Stresses in Reinforced Concrete Folded Plates by Finite Element Method," International Journal of Arts and Sciences, Volume 3, Number 9, 364-382 (2010). Bipin Pai, "Some helpful ideas in preparing the Self-Study," talk presented at the 2010 ABET Symposium, Alexis Park Resort, Las Vegas, N.V., April 15-17, 2010. Invited to present again at the 2011 ABET Symposium, Indianapolis, Ind., April 14-16, 2011. Bipin Pai, "What you need to do when planning for the ABET visit," talk presented at the 2010 ABET Symposium, Alexis Park Resort, Las Vegas, N.V., April 15-17, 2010. Bipin Pai, John Rowan and Brandon Rukes, "Redesigning Honors Program Leadership", talk presented at the Annual NCHC Conference, Kansas City, Oct. 20-23, 2010.

USING ONLINE QUIZZES AND DISCUSSION FORUMS TO ENHANCE LEARNING NUMERICAL METHODS

ABSTRACT

The use of quizzes to enhance learning outcomes has been used by educators in several courses to various degrees of success. On our campus the class on numerical methods has been offered for the past two summers as a hybrid course, with both the online and face-to-face components. As it is a course offered in the summer's shortened eight-week session, the 3-credit hour course in only a face-to-face class setting typically meets two hours, thrice a week. The hybrid course that was taught in the past two summers met once a week and the other two meetings were conducted as "online" meetings. The purpose of this paper is a description of how an existing course was transformed to a hybrid course and how the use of online activities such as quizzes and discussion forums has helped in the student performances in the course.

By assigning a substantial portion of the course grade to online quizzes and homework (in this course 20%), the author essentially forced the students to use the Blackboard Vista course management system (<http://blackboard.com>), which is available freely to our students on campus. The Blackboard Vista system is also available to students either on-campus or off-campus. Technology and skill requirements are made clear to the students who sign up for the course. The students are also made aware of the participation expectations. For the pilot study the author used online quizzes to help him in the teaching delivery of the numerical methods course. In addition, one of the other requirements for the online portion of the course was that all students had to participate actively in online discussion forums. Only 5% of the course grade was attributed to the online discussions. The students had to post at least one new discussion thread on a topic and respond to at least two others. The discussions were monitored by the author and the rules of "netiquette" were explained at the beginning of the course making it very clear that any use of "foul" language will not be tolerated. It was not very surprising to find that the students who took the online quizzes and who participated actively in the online discussion forums actually performed much better in their mid-term and final exams than those that didn't participate actively in the online activities. There were no control groups set to determine the effect of taking online quizzes and participating in online discussion forums. It just so happened that two or three students did not participate actively in the online quizzes and/or discussions. Therefore it was possible to do a comparison between those who participated in online activities with those who did not.

INTRODUCTION

As stated above, the pilot study to examine the effects of online quizzes and discussions to enhance learning outcomes was used in the Numerical Methods course taught by the author in the summer session. The Blackboard Vista course management system (<http://blackboard.com>), was used to access the online course. The online activities, i.e. quizzes and discussions could just as easily have been used in other courses as well. Also it would perhaps be useful to set up two groups in the same course, one who participate in the online quizzes and discussions and the other group not participating in any online activity. One has to be careful in assessing the two groups when their performances are compared to account for the fact that one of the groups did not have the opportunity to participate in the online quizzes or online discussions, especially if

credit is given for such online activities. The Numerical Methods course taught in Summer 2011 was offered as a hybrid course rather than a totally online course for several reasons including (1) the fact that although it was the second time that this course was offered as an online course, it was actually the first time that this course had online quizzes and online discussions, (2) the class met at least once a week face-to-face in order to answer questions that students for some reason chose not to ask online, and (3) the instructor was uneasy about conducting exams online.

METHODOLOGY

The course grading policy is explained to the students at the start of the semester and the breakdown is as follows. The mid-term and final exams count for 35% and 40% of the total grade respectively. Both exams are given in a face-to-face class session. Of the remaining 25%, homework and online quizzes count for 20% and the online discussions count for 5% of the total grade. The syllabus explained all the requirements, including the policies and expectations for online activities.

The Numerical Methods course is divided into four modules. The first module introduces the students to Taylor series, finite difference calculus, interpolation and extrapolation. The second module deals with roots of equations, solutions of simultaneous equations including matrix inversion and Gauss-Seidel iterative techniques. The third module covers least-squares curve fitting, Chebyshev economization, numerical integration including the trapezoidal rule, Simpson's rule, Romberg integration and Gauss quadrature. The fourth module exposes the students to numerical solution of ordinary differential equations including Runge-Kutta methods, Adams open and closed formulas and the predictor-corrector methods.

The online quizzes were used in the course to not only assess the student's knowledge of the subject matter but also to encourage the student to participate by awarding the students a substantial portion of the total grade (10%). Also the way it was structured in Blackboard, the students were allowed to retake the quiz. Allowing the students to retake the quiz relieved the stresses of taking the quiz. All students took the same quiz.

In addition, one of the other requirements for the online portion of the course was that all students had to participate in online discussion forums. Only 5% of the course grade was attributed to the online discussions. The students had to post at least one new discussion thread on a topic and respond to at least two others.

One of the reviewers was concerned about what was done to prevent collaboration in the online quiz. The entire point of encouraging students to participate in the online activities is to have them engaged in the course. The quiz scores by themselves are quite irrelevant as long as the students have learned the material. Another reviewer made some very good comments that generally numerical methods can be quite boring and he commended the use of online quizzes and discussion forums as a welcome stimulus. He did want to know the make-up of the class. Most of the students were graduate students and a few (about 15%) were undergraduate seniors.

RESULTS AND ANALYSIS

Table 1 shows the tool usage report of the online course. One can see that the maximum times used were in accessing files (20.39%), on assignments (18.85%), using folders (16.79%), on discussions (12.47%), and on checking grades (11.33%). Assessments (or quizzes) only used up 5.47% of the total online time. The relevance of this table is to bring out the amount of time students spent in taking the online quizzes and discussion forums.

Table 1: Tool Usage Report of the Online Course in Summer 2011

| Tool | Sessions | Average Time per Session | Total Time | Percent of Total Sessions |
|----------------|----------|--------------------------|------------|---------------------------|
| Announcements | 589 | 0:00:46 | 7:27:09 | 5.08% |
| Assessments | 912 | 0:00:32 | 8:01:19 | 5.47% |
| Assignments | 1038 | 0:01:36 | 27:39:58 | 18.85% |
| Calendar | 288 | 0:00:31 | 2:28:08 | 1.68% |
| Chat | 63 | 0:00:23 | 0:24:25 | 0.28% |
| Discussions | 1191 | 0:00:55 | 18:18:04 | 12.47% |
| File | 377 | 0:04:46 | 29:55:37 | 20.39% |
| File Manager | 166 | 0:00:42 | 1:56:52 | 1.33% |
| Folder | 1906 | 0:00:47 | 24:39:03 | 16.79% |
| Goals | 63 | 0:00:09 | 0:09:18 | 0.11% |
| Mail | 116 | 0:01:03 | 2:02:12 | 1.39% |
| My Grades | 694 | 0:01:26 | 16:37:32 | 11.33% |
| Notes | 11 | 0:00:26 | 0:04:41 | 0.05% |
| Printable View | 11 | 0:03:02 | 0:33:21 | 0.38% |
| Syllabus | 111 | 0:02:16 | 4:10:42 | 2.85% |
| Tracking | 24 | 0:00:32 | 0:12:39 | 0.14% |
| Weblinks | 15 | 0:00:05 | 0:01:18 | 0.01% |
| Who's Online | 160 | 0:00:47 | 2:04:46 | 1.42% |
| Total | 7735 | 0:20:44 | 146:47:04 | 100.00% |

Times given are in hours, minutes, and seconds.

Table 2 below indicates the summary of quiz usage. The quiz participation in the online course was excellent. All students took the quizzes, except one student missed both quizzes 5 and 6 and

it turned out that this student got the lowest overall score in the class. The means for all the quizzes were very high with an average mean score of 97.3% for the eight quizzes.

Table 2: Summary of Quiz Usage in Summer 2011
Numerical Methods Course (22 students)

| Quiz # | # of students who took quiz | Total # of times quiz taken | Total # of minutes used | Mean |
|--------|-----------------------------|-----------------------------|-------------------------|-------|
| 1 | 22 | 25 | 90 | 98% |
| 2 | 22 | 34 | 229 | 97% |
| 3 | 22 | 22 | 40 | 98.3% |
| 4 | 22 | 26 | 87 | 98.8% |
| 5 | 21 | 31 | 151 | 96.4% |
| 6 | 21 | 24 | 99 | 89.6% |
| 7 | 22 | 24 | 105 | 100% |
| 8 | 22 | 27 | 85 | 100% |

The following is an example of one of the quizzes used in the third module of the Numerical Methods course. One can see from the following example that there is a mix of simple questions and one slightly difficult. Some quizzes were longer than others but no quiz took more than 5 minutes of the student's time to answer all the questions, even though they were given 15 to 20 minutes per quiz.

Module 3 Quiz Example:

1 Least Squares Fitting

.

If the scatter suggests a quadratic behavior, fitting the scatter with a linear equation will still be a good choice.

| Student Response | Value | Correct Answer |
|------------------|-------|----------------|
| False | 100% | False |

Score: 10/10

Override score: / 10*

Comments for Student

2 Least Squares Fitting 2

If we know that the function is a power function $y = a \cdot x^b$, then

| Student Response | Value | Correct Answer | Feedback |
|---|-------|-------------------------------------|----------|
| 1. it is better to use the exponential data as it exists and do a linear least squares fit. | | | |
| 2. it is better to linearize the data by taking natural logarithms of both the independent and dependent variables and do a linear least squares fit. | | <input checked="" type="checkbox"/> | |
| 3. it is better to take the natural log of just the independent variable and do a linear least squares fit. | | | |
| <input checked="" type="checkbox"/> 4. it is better to take the natural log of just the dependent variable and do a least squares fit. | 0% | | |
| 5. it is better to use the exponential data as it exists and do a quadratic least squares fit. | | | |

Score: 0/30

Override score: / 30*

Comments for Student

3 Chebyshev Economization

Chebyshev economization helps us use lesser number of Taylor Series terms by using the Economization technique and most times with much less error.

| Student Response | Value | Correct Answer |
|------------------|-------|----------------|
| True | 100% | True |

Score: 10/10

Override score: / 10*

Comments for Student

Total score: 20/50 = 40% Adjust total score by: *

Comments for Student

Audit log comments:

Audit comments will only be saved when a grade change has been made.

*Scores will be rounded to 4 decimal places.

Table 3 below indicates the summary of discussion usage. Although the participation in online discussion forums were not as good as that of quizzes, it was still quite reasonable. Not all students participated in the discussion forums. For example in module 2, four students did not post even one message and similarly in module 4, five students did not post any message. The means for the discussion forums were not as high as that of the quizzes with an average mean score of 78% for the five discussion opportunities.

Table 3: Summary of Discussion Usage in Summer 2011
Numerical Methods Course (22 students)

| Discussion | # of students who posted messages | Total # of messages posted | Total # of minutes used in discussions | Mean |
|---------------|-----------------------------------|----------------------------|--|-------|
| Introductions | 20 | 40 | 27 | 91% |
| Module 1 | 20 | 69 | 107 | 59% |
| Module 2 | 18 | 59 | 46 | 67% |
| Module 3 | 20 | 64 | 72 | 90% |
| Module 4 | 17 | 46 | 85 | 82.3% |

It is interesting to note that although the discussions component was just 5% of the total grade, more time was spent on discussions (12.5% of total online sessions) rather than on the quizzes or assessments (5.5% of total online sessions).

The author and instructor of this course, was a little skeptical at first about even having discussion forums in a technical course, but he was surprised to see some healthy discussions that took place. Following are examples of two discussion threads.

(1) **Introductory Discussion** (40 Messages)

As seen in Table 3 above, 20 out of 22 students in the class did introduce themselves. The following statement on the introductory discussion (shown in italics) was posted by the instructor to solicit introductions from students.

“Every student in this online class is required to introduce themselves by say something about themselves. Examples of what you may share, but not limited to, are your major, your current status: first-year, sophomore, etc., if you are a graduate student: if this is your first year or second year, your favorite subjects. Please do not share any information that may be considered sensitive. Use your judgment on what information you want to share and what not to share.”

(2) **Module 2 Discussion Thread**

Here is a complete thread of one of the discussions. The names of the students are masked for obvious reasons, however the dates are provided and one can see that there were eight discussions on the same subject matter in less than 48 hours. Again the discussions are shown italicized. The last discussion in this thread is by the author and instructor of the course.

Compiled Messages

Topic: Module 2: Root Solving Methods, Solution of Simultaneous Linear Algebraic Equations, Polynomial Curve Fitting Date: Thursday, July 7, 2011; Subject: Guass Elimination and Gauss Jordan Elimination Author: Exxx Axxx Fxxx

Doing the exercises from chapter 6, I realize that if you don't have a computer code to help the calculations, the solution becomes very tedious and once the order of the matrix is increased, it becomes almost impossible to solve by hands (a lot of steps).

Date: Thursday, July 7, 2011; Subject: Re:Guass Elimination and Gauss Jordan Elimination
Author: Dxxx Cxxx Vxxx

Yes, you're right. Not just the fact of performing tedious calculations but also the odds to make mistakes increase. So, in the end you can realize that all your efforts didn't give you the correct answer.

Date: Thursday, July 7, 2011; Subject: Re:Guass Elimination and Gauss Jordan Elimination
Author: Uxxx Mxxx

Yes I tried to solve it by hand since I didn't know how to use the computer program so eventually I had to give up since it was almost impossible.

Date: Thursday, July 7, 2011; Subject: Re:Guass Elimination and Gauss Jordan Elimination
Author: Xxxx Lxxx

In my opinion, these algorithms are designed for computers. Because after we set those initial values and the entire loops, the computer will do those complicated calculations very fast and without mistakes. So I almost do all the calculations for ch6, ch7 and ch8 by now.

Date: Thursday, July 7, 2011; Subject: Re:Guass Elimination and Gauss Jordan Elimination
Author: Rxxx Vxxx Dxxx

I feel the same way. These algorithms are to be executed by computer programs else they are almost impossible to be solved by hand.

Date: Thursday, July 7, 2011; Subject: Re:Guass Elimination and Gauss Jordan Elimination
Author: Jxxx Sxxx

I agree. These calculations are so tedious it is hard to stay focused and complete the homework, especially because it is summer time and I am already working a full time job. The best way that I have found to solve matrices is by using Excel, inverting the matrix and multiplying.

Date: Friday, July 8, 2011; Subject: Re:Guass Elimination and Gauss Jordan Elimination
Author: Yxxx Pxxx

Actually, even for hand calculation, you can notice/find some ways to simplify your procedure. For example, when looking for the derivative or difference of the same data group, they turn out to be numerically same by shifting one column up or down.

Date: Friday, July 8, 2011; Subject: Re:Guass Elimination and Gauss Jordan Elimination
Author: Bipin Pai

Excellent discussion, guys. Remember in test situations you will need to know how to work out by hand. I checked your homework and many of you have either used Matlab or Excel to help you along. That is the intent of the course. So you understand the algorithms and then apply them using the software that you are familiar with. Hope you had the help of the flow charts shown in the textbook. In the earlier days of computing we had Fortran, Basic, then C. Nowadays we have C++, Matlab and Excel.

CONCLUSIONS

The present study was done in just one course, the Numerical Methods course in Summer 2011. Therefore it is hard to come up with definitive conclusions unless the study is continued in the future and used in other courses. However, the study did show some obvious results. Two students who did not perform well in the course either did not participate 100% in the online quizzes or the online discussions. It must be pointed out that it is hard to conclude just based on two students' performances. Another observation was that even though the discussions accounted for just 5% of the total grade, while the quiz component was 10%, more time was spent on discussions than on quizzes. Although the same course was taught in Summer 2010, online discussions were not used and only a few online quizzes were used, and therefore comparison of the courses taught in the two summer semesters will not yield any significant results. The author plans to use online quizzes and online discussion forums in other courses to determine the effect of these on the student's performance in the courses.

REFERENCES

1. Adrian Ieta, Alex Pantaleev, and Carolina C. Ilie (2011). "An Evaluation of the 'Just in Time Teaching' Method Across Disciplines." *2011 ASEE Annual Conference & Exposition*, Vancouver, BC, Canada.
2. Matthew W. Liberatore(2011). "Improved Student Achievement in Material and Energy Balances Using Personalized Online Homework." *2011 ASEE Annual Conference & Exposition*, Vancouver, BC, Canada.
3. Kirsten A. Davis. "Using No-Stakes Quizzing for Student Self-Evaluation of Readiness for Exams." *2011 ASEE Annual Conference & Exposition*, Vancouver, BC, Canada.
4. Sheryl A. and Dr. Carl R. Vilmann P.E. "Going Online with Statics." *2011 ASEE Annual Conference & Exposition*, Vancouver, BC, Canada.
5. Gwen Lee-Thomas, Ph.D., Autar Kaw, and Ali Yalcin. "Using Online Endless Quizzes as Graded Homework." *2011 ASEE Annual Conference & Exposition*, Vancouver, BC, Canada.