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Assessment of a Web-Enhanced Course in Numerical Methods*

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Effectiveness of web-based modules developed for a course in numerical methods was measured via three mixed assessment instruments—student satisfaction survey, student performance on a multiple-choice examination based on Bloom's taxonomy, and summative rating of the modules based on content, learning, usability and technology. The web-based modules are holistic and are customized based on a student's engineering major and choice of computational system. Statistical analysis of the assessment data indicates that web-based modules improved both student satisfaction and performance.

BACKGROUND AND PEDAGOGY

AT UNIVERSITY of South Florida (USF), we have developed web-based modules for faculty teaching and for students enrolled in a junior-level course in numerical methods. The features of the web-based modules are discussed only summarily in this article since the complete details are already available [1, 2]. Our main objective here is to report the implementation of the web-based modules and the assessment data to measure the effectiveness of these modules. *The authors emphasize that this paper is also being written to describe the assessment instruments (Appendices A, B, and C) so that educators who are creating web-based modules for other engineering courses can use them.*

The unique features of the web-based modules are that they are both *holistic* and *customized*. *Holistically*, the web-based modules (see Fig. 1) review essential course background information; present numerical methods through several options—textbook notes, presentations, simulations and assessments; show how course content covered is applied in real life; tell stories to illustrate special topics and pitfalls; and give historical perspectives to the material [1, 2].

From a *customized* view (see Fig. 2), faculty and students choose the web-based modules based on their preferred computational system—Maple [3], Mathcad [4], Mathematica [5], Matlab [6], and choice of engineering major—Chemical, Civil, Computer, Electrical, General, Industrial and Mechanical.

There are four primary reasons for developing simulations using multiple computational systems:

1. For continuity, cost, and pedagogy, a college may select and employ only one of these packages across their curriculum.
2. There is no additional cost involved if a university already has a site license to just one of the four computational systems.
3. Given a choice, students are typically reluctant to learn a second computational system if they already know one.
4. Those motivated can use an alternate computational system to gain greater proficiency in it.

There are three main reasons for developing simulations for seven engineering majors—Chemical, Civil, Computer, Electrical, General, Industrial and Mechanical:

1. Students are interested in acquiring knowledge and skills directly related to their major or career path. Typically, when numerical methods is taught, either instructors focus on the methods while paying little attention to showing applications in the engineering majors or they put most of the emphasis on solving engineering problems via computational systems while spending little time on the algorithms of numerical methods. The web-based modules allow the user to do both by choosing specific real-life examples to illustrate numerical methods applications and procedures from each of the engineering disciplines. For instance, a student majoring in civil engineering may choose an example pertaining to a structural engineering problem that needs to be solved numerically.
2. The examples from seven different engineering majors provide the critical cross-disciplinary opportunity for students and instructors to see how others use numerical methods.
3. It also gives a student access to seven different examples if he or she is facing difficulties in understanding a numerical method.

There is now considerable current research, much done with funding from the National Science Foundation (NSF) of USA, exploring how to

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LANGUAGE: **MATHCAD** **INTERPOLATION** MAJOR: **GENERAL**

Background

What is interpolation? [PDF] [DOC]
History of interpolation [PDF] [DOC]
Test your knowledge on background of interpolation [HTML] [PDF] [DOC]

Physical problem

The upward velocity of a rocket is given as a function of time. To find the velocity of the rocket at some other time, the problem requires interpolation. [PDF] [DOC]

Numerical method

Direct method:

How does the direct method work? [PDF] [DOC]
A Power point presentation [PDF] [PPT]
Simulations of the method [PDF] [MCD]
Anecdotes and special topics [GO]
Test your knowledge of the method [HTML] [PDF] [DOC]

Newton's divided difference polynomial method:

How does the Newton's divided difference polynomial method work? [PDF] [DOC]
A Power point presentation [PDF] [PPT]
Simulations of the method [PDF] [MCD]
Anecdotes and special topics [GO]
Test your knowledge of the method [HTML] [PDF] [DOC]

Lagrangian method:

How does the Lagrangian method work? [PDF] [DOC]
A Power point presentation [PDF] [PPT]
Simulations of the method [PDF] [MCD]
Anecdotes and special topics [GO]
Test your knowledge of the method [HTML] [PDF] [DOC]

Spline method:

How does the spline method work? [PDF] [DOC]
A Power point presentation [PDF] [PPT]
Simulations of the method [PDF] [MCD]
Anecdotes and special topics [GO]
Test your knowledge of the method [HTML] [PDF] [DOC]

Anecdotes

The lurking dangers of extrapolation! [PDF] [DOC] [MCD]
Why higher order interpolation is is a bad idea? [PDF] [DOC] [MCD]
Comparison of spline and polynomial interpolation. [PDF] [DOC] [MCD]
How choice of points of interpolation affects approximations! [PDF] [DOC] [MCD]
How splines can help in developing a shorter path for a robot! [PDF] [DOC] [MCD]

Fig. 1. Web-based modules for interpolation using Mathcad for general engineering.

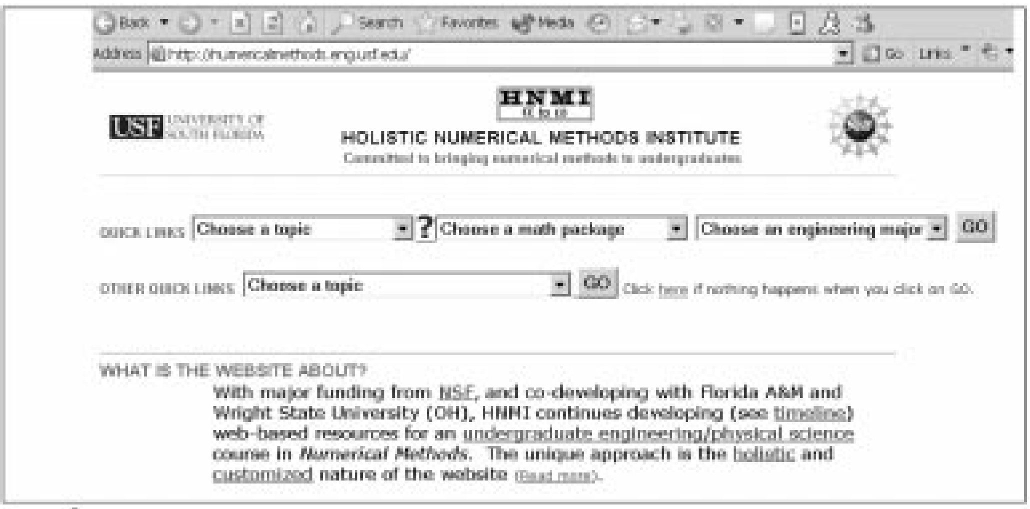

Fig. 2. Home page of the holistic numerical methods institute—committed to bringing customized numerical methods holistically to undergraduates.

enhance student learning in science, mathematics, engineering and technology (SMET) courses. This literature greatly influenced and guided the work presented in this paper. Especially relevant to this paper, for example, is work summarized in the outstanding text *How People Learn* [7].

For example, we know that experts (that is, faculty) '*often forget what is easy and what is difficult for students* [7, p. 32].' Our web-based modules offers both students and faculty a comprehensive instructional package for simplifying and enhancing the teaching of numerical methods across the engineering curriculum.

Further, research has demonstrated that it is beneficial to provide '*instruction that enables students to see models of how experts organize and solve problems*' and that '*the level of complexity of the models must be tailored to the learners' current levels of knowledge and skills* [7, p. 37].' The design and format of the web-based modules helps students see how experts apply fundamental numerical methods to solve real world engineering problems both within and across different engineering disciplines.

And finally, citing again from this same synthesis of research findings, we know that '*A major goal of schooling is to prepare students for flexible adaptation to new problems and settings'* [7, p. 65] and that '*knowledge that is taught in only a single context is less likely to support flexible knowledge transfer than knowledge that is taught in multiple contexts'* [7, p. 66]. Our effort was to provide an instruction opportunity to suit different learning styles [8]. In a survey conducted with 50 students at USF in Spring 2003, when asked about how they learned best [8], the results were as follows: apprenticeship (42%), incidental (24%), inductive (22%), deductive (8%), and discovery (4%) [9]. By enabling students to select both a preferred computational system as well as to select one or more illustrative examples drawn from seven popular engineering majors within each topic area, these interactive instructional modules maximize the likelihood of lasting and flexible learning transfer of essential numerical methods course content.

IMPLEMENTATION AND ASSESSMENT INSTRUMENTS

In 2002, we started to develop prototype web-based modules for two topics in a typical numerical methods course—Nonlinear Equations and Interpolation. These topics were selected for the prototype, as these are some of the first topics taught in a numerical methods course. In the summer semester of 2002, the web-based modules were still in the initial stages of development. This was an appropriate time to measure the student satisfaction and performance *without* the web-based modules.

To measure student satisfaction, a survey was developed that was divided into three distinct sections—reading assignments, class presentations, and problem sets. Each section consisted of the same eight questions that are given in Appendix A. Students answered the questions on the survey using a Likert [10] scale from 1 (truly inadequate) to 7 (truly outstanding).

To measure the student performance, we asked 12 multiple choice questions (6 questions each from Nonlinear Equations and Interpolation) as part of the final examination. The six questions on each topic were based on the corresponding six levels of Bloom's taxonomy—*knowledge, comprehension, application*, *analysis, synthesis, and evaluation* [11]. A sample of the final examination questions from Nonlinear Equations are given in Appendix B.

Having collected the assessment data from the above two instruments—student satisfaction and performance in the summer semester of 2002—we first implemented and tested the web-based modules tentatively in the spring semester of 2003. The modules were then implemented fully in the summer semester of 2003 as follows.

Reading assignments

For reading assignments and as a reference to class presentations, the students used the textbook notes from the web-based modules (Fig. 1) rather than the assigned commercial textbook. Since the modules were developed for seven different engineering majors, they had access to seven different examples for each numerical method.

Classroom presentations

Before discussing numerical methods for a mathematical procedure, we conducted an in-class and informal diagnostic test on students' background information via several questions. This allowed us to review specific material that most students struggle with.

We used PowerPoint presentations to present the Numerical Methods. These presentations were continually supplemented with discussions based on instructor and student questions. Several times during the presentation, students were also paired in class to work out an iteration or a small problem.

Once a week, we met in a computer classroom where each student has access to a computer. Simulations for various numerical methods were conducted. Some of the anecdotal simulations included exercises such as:

- showing higher-order interpolation is a bad idea,
- that extrapolation is dangerous, and
- finding a smooth path of a robot

were programmed in Maple by students themselves. This active participation was critical to create a deeper understanding and ownership of the course material.

Problem sets

Modeled after Bloom's taxonomy [11], we developed multiple-choice problems for pre-requisite information and each numerical method. These problems are available on the course website and feedback is immediate. We also developed other problem sets where students needed to work problems through several steps.

To find the effectiveness of the web-based modules, in summer semester of 2003, we used the same assessment instruments of student satisfaction survey and final examination performance as used in summer semester of 2002.

In the semesters when the web-based modules were available, that is spring semester of 2003 and summer semester of 2003, we used an additional assessment instrument to assess the web-based modules. This instrument gave a summative rating of the web-based modules and was derived from the work by Sonwalker [8, 12, 13]. A questionnaire (Appendix C) was designed specifically for this investigation and it asked questions on four major factors:

1. Content—quality, accuracy, validity, presentation, media quality, and source credit;
2. Learning—identifying concepts, learning style, media enhancements, and assessment tools;
3. Usability—graphical user interface, interactive design, clarity, appropriateness of length, and page layout; and
4. Technology—time to download, ability to access, and compatibility of browser.

The questions are based on technology standards proposed by IMS [14], AICC [15], and SCORM [16]. Students rated each of the questions using a five point Likert [10] scale: 0 for absent to 4 for excellent.

ASSESSMENT RESULTS

Three assessment instruments [1, 8, 11–13, 17–19]:

- student satisfaction survey (Appendix A),
- multiple choice question final examination based on Bloom's taxonomy (Appendix B) [11], and
- summative rating of web-based modules based on multiple factors (Appendix C) [8, 12, 13]

were used to measure the effectiveness of the web-based modules for instruction.

Both the summer semesters of 2002 and 2003 were 6 week-long sessions. One may question that the students taking classes during summer may not represent a true sample of the student population, but actually, the demographics of students taking summer classes are not significantly different from those in the academic semesters of fall and spring because:

1. USF is an urban university and hence has a large segment (47%) [9] of part-time students (those who take less than 12 credit hours per semester) who take courses throughout the calendar year.
2. All students in USF are required to take at least 9 credit hours of coursework in summer semester during their undergraduate program.
3. The numerical methods course is offered only during the spring and summer semesters.

Henceforth, Summer 2003 is referred as the semester where web-based modules were used and Summer 2002 as the semester where web-based modules were not used.

Student satisfaction survey

Student satisfaction surveys were given in Summer 2002 (without web-based modules) and in Summer 2003 (with web-based modules). Surveys (Appendix A) were given on the individual topics of Nonlinear Equations and Interpolation.

Results of the student surveys (means and two-sample t-test) from Summer 2002 (without web-based modules) and Summer 2003 (with web-based modules) are given in Table 1a and Table 1b for Nonlinear Equations and Interpolation, respectively. Note that since the sample size (that is, 42 students in Summer 2002 and 27 students in Summer 2003) is low, design of experiments techniques (that is, t-test) have been used to validate the accuracy of the results.

In Tables 1, the t-value is the test statistic and the p value (or performance measure) is the value of the t-distribution at the test statistic (or the right tail of the distribution) [20, chapter 2]. Note that the confidence level, in percent, is simply equal to 100% times one minus the p value.

Tables 1a and 1b indicate that the web-based modules were very effective for interpolation and nonlinear equations with a greater than 99.9% level of confidence that the web-based modules increased overall student satisfaction including the individual areas of reading assignments, class presentations and problem sets. Furthermore, as a result of using web-based modules, the overall student satisfaction increased by about three-quarters to one-point on the seven-point Likert scale.

Multiple-choice final examination based on Bloom's taxonomy

How well students performed in the course with and without web-based modules was found by asking twelve multiple-choice questions on the final examination. See Appendix B where a sample of questions are given. These are not the actual questions asked in the final examination as the final examination continues to be used as an assessment instrument. The twelve questions are comprised of

1. Six questions on nonlinear equations:
   - Three at the lower level (*knowledge, comprehension, application)* of Bloom's taxonomy
   - Three at the higher level (*analysis, synthesis, and evaluation)* of Bloom's taxonomy
2. Six questions on interpolation
   - Three at the lower level of Bloom's taxonomy
   - Three at the higher level of Bloom's taxonomy

Table 1a. Results of surveys on nonlinear equations (number of samples, means, t-values, p-values, and percent confidence level) with and without web-based modules.

Questions on nonlinear equations	Without Web		With Web		Score difference	t value	p value	Confidence level (%)
	N	Mean	N	Mean				
Reading assignments (8)	304	4.17	216	4.68	+0.51	−4.60	<0.001	>99.9
Class presentations (8)	304	5.03	216	5.78	+0.75	−7.56	<0.001	>99.9
Problem sets (8)	305	4.49	216	5.35	+0.86	−8.76	<0.001	>99.9
All questions (24)	913	4.57	648	5.27	+0.70	−11.22	<0.001	>99.9

Table 1b. Results of surveys on interpolation (number of samples, means, t-values, p-values, and percent confidence level) with and without web-based modules.

Questions on interpolation	Without Web		With Web		Score difference	t value	p value	Confidence level (%)
	N	Mean	N	Mean				
Reading assignments (8)	346	3.57	216	4.58	+1.01	−9.96	<0.001	>99.9
Class presentations (8)	345	4.43	216	5.61	+1.18	−11.61	<0.001	>99.9
Problem sets (8)	344	4.06	216	5.28	+1.22	−12.65	<0.001	>99.9
All questions (24)	1035	4.02	648	5.16	+1.14	−18.65	<0.001	>99.9

Table 2. Results of final examination scores (number of samples, means, t-values, p-values, and percent confidence level) with and without web-based modules

Category of final examination	Without Web		With Web		Score difference	t value	p value	Confidence level (%)
	N	Mean	N	Mean				
Total	42	6.45	27	7.44	+0.99	−2.50	0.008	99.2
Nonlinear equations	42	3.40	27	3.74	+0.34	−1.16	0.127	87.3
Interpolation	42	3.05	27	3.70	+0.65	−3.10	0.001	99.9
Low level Bloom	42	3.12	27	3.67	+0.55	−2.22	0.016	98.4
High level Bloom	42	3.33	27	3.78	+0.45	−1.54	0.085	91.5

Table 3. Results of pre-requisite GPA with and without web-based modules.

Mean GPA	Without Web		With Web		Score difference	t value	p value	Confidence level (%)
	N	Mean	N	Mean				
Pre-Requisites	42	2.59	27	2.81	+0.22	−1.06	0.146	85.4

Each correct answer is given a score of 1 and an incorrect answer is given a score of 0, for a total of 12 possible points. Table 2 shows that the final examination scores increased in each category in Summer 2003 when web-based modules were used. Furthermore, in some instances, there is a high level of confidence (that is, greater than 90%) that the final examination scores increased as a result of web-based modules.

However, we found that the mean GPA (Table 3) in the pre-requisite mathematics courses (that is, Calculus I, Calculus II, Calculus III, and Ordinary Differential Equations) of students in Summer 2003 was nearly 9% higher (2.81 on a scale of 4) than in Summer 2002 (2.59 on a scale of 4).

This leads to a question: *Did the final exam scores improve in Summer 2003 because of the introduction of the web-based modules or was it the higher mean pre-requisite GPA (MPGPA) of the students?* To address this question, students' final examination scores in both semesters were separated (see Table 4), based on two criteria:

1. Pre-requisite GPA was above or below the MPGPA (2.68 on a scale of 4 for all students in both summer semesters of 2002 and 2003) of both semesters (42 students in Summer 2002 without web-based modules, and 27 students in Summer 2003 with web-based modules).
2. Web-based modules were used or not.

Table 4 indicates that in all aspects of the final examination, the students with pre-requisite GPA above MPGPA performed better than the students with pre-requisite GPA below MPGPA. Furthermore, regardless of pre-requisite GPA, students with web-based modules performed better on the final examination in all categories but two. These two categories were:

1. Score in nonlinear equations for students below MPGPA.

Table 4. Mean final examination scores for above and below MPGPA, with and without use of web-based modules.

Classification based on MPGPA & with and without web-based modules		N	MPGPA	Final examination score				
				Total	Nonlinear equations	Interpolation	Low level Bloom	High level Bloom
All Students		69	2.68	6.84	3.54	3.30	3.33	3.51
Below	All Students	29	2.02	6.43	3.14	3.30	3.16	3.27
MPGPA	Without Web	17	2.08	6.28	3.16	3.12	3.00	3.28
	With Web	12	1.90	6.75	3.08	3.67	3.50	3.25
Above	All students	40	3.44	7.31	4.00	3.31	3.53	3.78
MPGPA	Without Web	25	3.34	6.71	3.76	2.94	3.29	3.41
	With Web	15	3.55	8.00	4.27	3.73	3.80	4.20

Table 5. Two-factor design of experiments.

Number of students		Factor B Web-based modules	
		Level 1 without Web	Level 2 with Web
Factor A Pre-requisite GPA	Level 1 Below MPGPA	17	15
	Level 2 Above MPGPA	25	12

Table 6. Results for a two-factor ANOVA design of experiments.

Final examination score	Source of variation	F	Is the event significant?	p-value	Confidence level (%)
Total	GPA	5.44	Yes	0.023	97.7
	Web	5.08	Yes	0.028	97.2
	GPA & Web	1.12	No	0.294	70.6
Nonlinear equations	GPA	11.54	Yes	0.001	99.9
	Web	0.64	No	0.427	57.3
	GPA & Web	1.21	No	0.275	72.5
Interpolation	GPA	<0.01	No	0.947	5.3
	Web	8.16	Yes	0.006	99.4
	GPA & Web	0.28	No	0.602	39.8
Low level Bloom	GPA	2.41	No	0.125	87.5
	Web	4.20	Yes	0.044	95.6
	GPA & Web	<0.01	No	0.990	1.0
High level Bloom	GPA	3.56	Yes	0.064	93.6
	Web	1.80	No	0.184	81.6
	GPA & Web	2.14	No	0.149	85.1

2. Score in the High Level Bloom category for students below MPGPA.

Hence, students' use of web-based modules shows improved scores; however, the effect of the web is not perfectly evident yet.

To determine further the effect of the web-based modules, a two-factor ANOVA design of experiments (that is, an Analysis of Variance) with two levels for each factor, was performed [20, chapter 3]. An Analysis of Variance is used to compare student performance based upon various factors, such as, web-based instruction and MPGPA. The rationale for performing a two-factor design of experiments is to determine the performance of the well-prepared students (that is, pre-requisite GPA higher than MPGPA) and poorly-prepared students (that is, pre-requisite GPA lower than MPGPA), with and without the use of web-based modules.

A general linear ANOVA model [21, chapter 10] was used because the number of responses (data points) for each factor and level is different. In the design of experiments [20, chapter 3], Factor A was pre-requisite GPA with levels 1 and 2 meaning below and above MPGPA, respectively; Factor B was web-based modules with levels 1 and 2 meaning without and with web-based modules, respectively. The number of data points for each factor and level is shown in Table 5.

Note that from the results in Table 4, the difference in final examination scores from one level to another level is not the same for each factor. For example, with web-based modules the score in Nonlinear Equations for students above MPGPA increased from 3.76 to 4.27, while for students below MPGPA the score decreased from 3.16 to 3.08. When this occurs, interaction between factors, although small, is taking place and must be considered in the experiment.

Table 6 shows the results of the two-factor, with interaction, design of experiments for a level of confidence of $\alpha = 0.10$ (or 90% confidence that the claim can be made) in the results [21, chapter 10]. In Table 6, F is the test statistic based on the F-distribution and F_α is the F-distribution evaluated at α. Note that the event (that is, combination of the final examination score and the source of variation) is considered significant when F is greater than F_α. Also, note that an alpha level of 0.10 is chosen to conclude that the observance is not merely a chance occurrence, and that the F-distribution evaluated at $\alpha = 0.10$ is $F_\alpha = 2.76$.

The results in Table 6 can be summarized as follows:

- *Effect of pre-requisite GPA (Factor A)*. The effect of the pre-requisite GPA on the final examination score is significant with a 90% confidence level ($\alpha = 0.10$) for Total, Nonlinear Equations, and High Level Bloom scores. In summary, students with pre-requisite GPA higher than MPGPA perform better on these scores.
- *Effect of Web-based modules (Factor B)*. The effect of web-based modules on the final examination score is significant with a 90% confidence level ($\alpha = 0.10$) for Total, Interpolation, and Low Level Bloom scores. Thus, students with web-based modules perform better on these scores.
- *Effect of pre-requisite GPA and web-based modules interaction*. The effect of the interaction between GPA and use of web-based modules on the final examination score was not significant ($\alpha = 0.10$). In other words, there was no noticeable interaction between pre-requisite GPA and the use of web-based modules, with regards to the final examination scores.

Since there is no significant interaction between factors, it can be stated with 90% confidence level that use of web-based modules did increase the final examination scores, especially total final examination score, regardless of the pre-requisite GPA.

Outside of the obvious inferences that are drawn above, there are other conclusions that can be drawn from the information presented in Table 6. For instance, the MPGPA of students did not have an effect on the interpolation score, however it did have a significant effect on the nonlinear equations score.

Summative rating of web-based modules

The web-based modules were summative rated in four categories of content, learning, usability and technology (Appendix C). The results are given for the semesters when the web-based modules were available, that is, in Spring 2003 and Summer 2003 semesters. The results for each of the four factors and the summative rating of web-based modules (that is, average value of the four factors) are given in Table 7.

Table 7. Summative rating (0 for absent, 4 for excellent) of the web-based modules.

Factor	Spring 2003	Summer 2003
Content	3.13	3.45
Learning	2.77	3.03
Usability	3.04	3.01
Technology	3.28	3.43
Summative rating of web-based modules	3.05	3.23

CONCLUSIONS

The effectiveness of web-based modules is measured and shown to be successful for a course in numerical methods. First, we see an increase (with greater than 99.9% confidence) in student satisfaction, based on surveys, in three areas—classroom presentations, reading assignments, and problem sets. Secondly, we found an increase in student performance via a twelve-question multiple-choice examination that was formulated using Bloom's Taxonomy. This increase in student performance, based on web-based resources for instruction, occurred in all categories such as individual topics and levels of Bloom's Taxonomy with a greater than 85% confidence level. Furthermore, in many of the categories, the increase in student performance was regardless of the grades in the pre-requisite mathematics courses. Thirdly, students' summative rating of the web-based modules based on four factors—content, learning, usability, and technology, is improving as modules are being revised and added.

FUTURE STUDY

Based on the positive findings in this paper, the feedback received from students and instructors, and with renewed funding from National Science Foundation of USA until March 2007, we are adding web-based modules for four more topics—Simultaneous Linear Equations, Regression, Integration, Differential Equations. We plan to seek funding in 2006 for two more modules—Differentiation and Fundamentals of Scientific Computing to complete the resources for a typical undergraduate course in numerical methods.

Starting Fall 2004, we are using the three assessment tools for a longitudinal study not only at University of South Florida, but also at Florida A&M University (FAMU) and Wright State University (WSU). This partnership among three universities will allow us to measure the effectiveness of the web-based modules in a diverse student population:

- underrepresented minorities and women in engineering (FAMU);
- transfer and over traditional-age adult students (USF);
- diverse engineering majors—Mechanical, Electrical, Chemical, and Biomedical;
- class sizes—small (FAMU), medium (WSU), and large (USF);
- computational systems (Matlab at FAMU and WSU, and Maple at USF).

We anticipate formally presenting and publishing the assessment results for the full course in 2008.

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APPENDIX A

Student satisfaction survey

This survey is anonymous. Please answer the following 24 questions with only one of the following seven responses: truly outstanding, excellent, very good, good, adequate, poor, and truly inadequate.

READING ASSIGNMENTS (QUESTION# 1 TO 8)

1. READING ASSIGNMENT: In terms of the value of helping me acquire basic knowledge and skills, I'd say that the reading assignments were _______________.
2. READING ASSIGNMENT: In terms of their value in reinforcing information presented in class presentations and in the problem sets, I'd say that the reading assignments were _______________.
3. READING ASSIGNMENT: In terms of their value in helping me learn to clearly formulate a specific problem and then work it through to completion, I'd say that the reading assignments were _______________.
4. READING ASSIGNMENT: In terms of their value in helping me develop generic higher-order thinking (e.g. analysis, synthesis and evaluation from Bloom's taxonomy handout given in class) and problem solving skills, I'd say that the reading assignments were _______________.
5. READING ASSIGNMENT: In terms of their value in helping me develop a sense of competence and confidence, I'd say that the reading assignments were _______________.
6. READING ASSIGNMENT: Overall, I'd say that the clarity of explanations contained in the reading assignments were _______________.
7. READING ASSIGNMENT: In terms of helping me see the relevance of the course material to my engineering major, I'd say the reading assignments were _______________.
8. READING ASSIGNMENT: Overall, I'd say that the helpfulness of the illustrative examples and practical applications contained in the reading assignments were _______________.

Eight identical questions as given above are asked about **class presentations** and **problem sets**.

APPENDIX B

Final examination based on Bloom's taxonomy

Circle the most appropriate answer.

1. For a certain cubic equation, at least one of the roots is a complex number. How many roots of the cubic equation are complex numbers?
   (A) one
   (B) two
   (C) three
   (D) cannot be determined.
2. If for a real and continuous function $f(x)$, $f(a)f(b) < 0$, then in the range of $[a, b]$ for $f(x) = 0$, there is (are)
   (A) one root
   (B) undeterminable number of roots
   (C) no root
   (D) at least one root
3. Assuming an initial bracket of $[1, 5]$, the second (after 2 iterations) iterative value of the root of $te^{-6} - 0.3 = 0$ by bisection method is
   (A) 0.0
   (B) 1.5

(C) 2.0
(D) 3.0

4. The root of equation $f(x) = 0$ is found by using Newton-Raphson method. The initial estimate of the root is $x_0 = 3$, and $f(3) = 5$. The angle the tangent makes to the function $f(x)$ at $x = 3$ is 57^0. The next estimate of the root, x_1 most nearly is
(A) -3.2470
(B) -0.2470
(C) 3.2470
(D) 6.2470
5. The root of an equation is found by using the Newton-Raphson method. The successive iterative values of the root are given in the table below

Iteration Number	Value of Root
0	2.0000
1	1.6667
2	1.5911
3	1.5874
4	1.5874

What is the minimum iteration number when you would trust at least two significant digits in your answer?
(A) 1
(B) 2
(C) 3
(D) 4
6. The ideal gas law is given by $pv = RT$ where p is the pressure, v is the specific volume, R is the universal gas constant, and T is the absolute temperature. This equation is only accurate for a limited range of pressure and temperature. Vander Waals came up with an equation that was accurate for larger range of pressure and temperature given by

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT,$$

where a and b are empirical constants dependent on a particular gas. Given the value of $R = 0.08$, $a = 3.592$, $b = 0.04267$, $p = 10$ and $T = 300$ (assume all units are consistent), one is going to find the specific volume, v, for the above values. Without finding the solution from the Van der Waals equation, what would be a good scientific initial guess for v?
(A) 0
(B) 1.2
(C) 2.4
(D) 3.6

APPENDIX C

Summative rating of web-based modules

This survey is anonymous. Please answer the following questions with only one of the following five responses: Excellent, Good, Average, Poor or Absent. The 18 statements are classified under four categories of A) Content B) Learning C) Usability, and D) Technology [13].

A) Content

1. The quality of the content was _____________.
2. The accuracy of the content was _____________.
3. The validity of the content of the website in relation to the course objectives was __________.
4. The presentation of the content was _____________.
5. The quality of media such as simulations, audio and video was _____________.
6. Giving sources and author of content proper credit was _____________.

B) Learning

7. Your ability to identify concepts from the web site was _____________.
8. How well the website matched your learning style was _____________.
9. How well the media enhancements such as simulations, videos, etc. helped you learn was _____________.
10. The multiple choice question exams were _____________.

C) Usability

11. The graphical user interface, such as graphics, type font and navigation bars, was _________.
12. The interactive design of the web site was _____________.
13. The clarity of the web site was _____________.
14. The appropriateness of the length of the individual pages of the web site was ____________.
15. The page layout and ease of access from other pages of the web site was _____________.

D) Technology

16. The time it took you for downloading web pages was _____________.
17. The ability to access the web pages was _____________.
18. The compatibility of the browser you used with the website was _____________.