ROM AND RAMBLE
Combining New Technologies and Old Methods For Better Learning and Use of Time

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Abstract

In the Fall 2000 semester we taught 76 students in a fundamentals in chemical engineering class using a method combining traditional and new technologies. The course was semi self-paced in that students could complete it as quickly as they wished or were able, but no slower than a minimum rate to take the final comprehensive examination. All content was provided in a CDROM specifically prepared for this course and to enable a high degree of independent learning. Students were required to meet as a class with the professor one day a week and the other two days were used for helping those who needed more attention and for taking modules mastery tests. The CDROM contained12 modules through which students progressed at there pace by passing mastery tests. Although we had previously tested this method with a class of 27 and made statistical comparisons with a traditional lecture methods section, this was our first time to use the method in a large enrollment format. We present data on student performance, motivation, learning styles, successes and failures. Finally, details about faculty time on various tasks are presented and compared to those for a traditional lecture class.

I. Introduction

After several hundred years of practice, there must be some attributes of the standard lecture methods of teaching that are worth keeping. Likewise, with all the hyperbole and data about information technologies for better learning, there must be some truth and useful results. In our ongoing experiments we are attempting to meld those positive attributes of the traditional and the advantages of the new technologies so that better learning results. With better learning we believe must come better use of faculty and student time. Most of us agree that nothing can be better than the gifted, inspired and dedicated teacher working with his or her students in lecture or any other format. However, too few professors are inspired, fewer are dedicated and much fewer are gifted. So, the majority of us would like to use the new technologies in some way to be better teachers and for our students to be better learners. Some zealots go so far as to claim the new era of learning lies entirely with some form or other of new technologies. We don't believe so. Over the past couple of years we have been testing and evaluating an approach that provides the course content on a CDROM and the WWW, frees students to move through the course at a rapid pace and permits the faculty much more time to work with those students who need special attention. There is almost no lecturing.

II. History

Our work has been with an introductory course in chemical engineering. Typically, this is the first chemical engineering course taken by the majors and it usually comes in the second year of their studies. It might be called Chemical Engineering Fundamentals, Principals and Practices of Chemical Engineering or some similar title. It is the foundation upon which many other advanced chemical engineering courses are based. It is usually the students' first taste of our discipline and often their first time to differentiate the studies of chemical engineering from chemistry.

In the Fall of 1999 we conducted a detailed comparative study between our method and the traditional lecture method (1). A section of 52 students was taught in the full, traditional lecture method of 50-minute periods, three times a week. Another section of 27 students was taught by our test method. Results have been presented on our findings (1,2,3). In the Fall 2000 semester, all of our students (87) were enrolled in this new method and detailed data were taken to evaluate their learning, teacher time on tasks and student attributes. Before presenting some of our results, here is a brief review of our method of teaching and learning.

III. New Method

More details on this method have been presented previously (1,2,3,4). A CDROM contained most of the course content. New material is merged where appropriate by the WWW. No text was required but two standard and commonly used texts were strongly recommended for the students' professional bookshelf. The course was managed by WEBCT. There were 12 modules over which every student had to be tested for mastery and all students sat at the same time for the final examination. The professor published the minimum rate at which the students had to pass each mastery test. However, here is one significant advantage; the students were free to progress through the modules as rapidly as they wished. Some students finished the course well before the last day of classes.

On Monday and Friday, the students did not have to attend the scheduled class; these days were used for taking mastery tests and for special tutoring by the professor. Wednesday was a "required" attendance class where the professor conducted team projects, gave 10-point quizzes, conducted demonstrations and generally introduced enriching material. There were few lectures on Wednesdays and the module material was not reviewed. So, students were compelled to learn the material on their own or come to the professor for tutoring on Mondays and Fridays as needed. The professor's time was redirected from lecture preparations and presentations to test preparations, grading, Wednesday's activities and, most importantly, to helping those students who most needed assistance. No teaching assistants were used to grade the mastery tests in order to closely track student performance.

The CDROM was especially prepared for this approach (3,4). It had only the minimum content, that is the most important material we wanted our students to know but not the

special cases, most of which are addressed in other classes. The CDROM was not intended to compete with or to replace a textbook. All concepts were illustrated by example and there were additional example problems and practice problems. Of course, the power of multimedia through animation, illustrations, sound and nonlinear formatting was incorporated. We hoped to accommodate different learning styles.

This approach brings together some of the useful elements of information technology yet keeps the professor closely connected with the students.

lV. Some Results

A. Time on Tasks

Our approach greatly redistributes how professors use time for a given class, at least compared to the traditional lecture method. Table 1 shows that class preparation and lecturing for the traditional approach took 58 % of the total time on tasks compared to 13 to 22 % time for our new method. Adjusting for student class size, time given to tutoring and assisting students in our approach was twice that for the lecture method (20% vs. 11%). The greatest difference lies in test grading. Because the students in the new approach could repeat testing for modules mastery without penalty (only highest score counts) up to the due date, many repeated testing to increase scores. As a result, much time was needed to grade all of the tests. Because we were intent on evaluating the method, only the professor graded the tests, not teaching assistants. Of the total time on tasks, about 40% of the time was used for grading compared to only 26% for the lecture method. These, too, are adjusted for enrollment size. We feel that this is one aspect of our approach that should be changed. Students in the future classes will be permitted to take each modules mastery test only twice and the highest score to count. Too often students were past the point of learning the concepts and only interested in making a few more points, or some were first testing to just see what the examinations were like, that is "fishing."

Table 1
Professor's Time on Tasks
(Percent of Total Course Time)

Task	Lecture	New Method
Class Preparation and Presentations	58%	13-22%
Student Tutoring	11	20
Tests Grading	26	40
Other	5	18-27

The total faculty time on course tasks is something we all are interested in, especially administrators. Comparing the Fall '99 lecture class of 52 students and the Fall '00 new method class of 76 students and adjusting for enrollment size,

about the same time was required of the professor. However, reducing to only two or even one modules mastery test will result in a significant savings – about 25% less total time relative to the lecture method. Do not lose the important fact — the real value in our method lies in freeing students who are capable to progress at a faster rate and opening time for the professor to work with students who need more assistance.

B. Student Performance

Another important issue is how well do students learn. Is there better learning or at least the same learning? Table 2 shows the results of pretest and the final semester examinations results for the ’99 and ’00 semesters. This shows that the starting point (pretest) for all sections was the same and the results on the final examinations were identical, at the 95% confidence level. Of course we had hoped to show higher results on the final test for our new method but at least there are other significant benefits as noted above and more are mentioned below. The grade distributions and number of students who dropped the class were similar in each of the sections.

Table 2
Test Results

	’99 Lecture			’99 New			’00 New		
	Mean	N	SD	Mean	N	SD	Mean	N	SD
Pretest	55	42	14	56	26	14	45	55	17
Final Exam	143	47	29	128	26	34	132	76	34

Note the number of students, N, varies from the enrollment because not all agreed to participate.

C. What Characterizes a Successful Student?

In addition to measuring prior knowledge with the pretest, we examined four categories of characteristics that have been found in other research to be important. First, we looked at two approaches to studying. The first approach we called self-regulation, which is when students consciously think about how they are studying and the effectiveness of their study methods. The second approach, we call “shallow” as it describes students who tend to use memorization as their main study strategy. The second category we examined is student confidence in the ability to be successful in the course. The third examined student goals related to course performance. The final category was learning style preferences.

A survey was designed to collect data on demographic and relevant educational experience. The pre-test measured entering knowledge on key concepts related to the course. The Demographic Survey and Pretest were administered at the beginning of the course.

An Approach to Learning survey was designed to assess the following constructs: 1) goals, including learning and future goals; 2) self-efficacy for success in the class, for background content considered prerequisites, and in the delivery system; study strategies; and 4) learning styles including sequential, active thinking (1), and sensing. This survey was administered midway through the course, just before the midterm exam.

Table 3
Response Rate by Instrument

	Enrolled	Final	Participants	Pretest	Approaches
Number	87	73	66	55	62
Percent	100	83.9	75.9	63.2	71.3

Table 3 shows of the 87 students enrolled in the course, 66 agreed to participate in the study. Over one-half of the students were sophomores (56 %) and 30 % were juniors by university hours but still only sophomores by chemical engineering hours. Over three-fourths (77 %) indicated that English was their first language. Table 4 examines the prior learning in key subjects.

Table 4
Prior Credit Hours in Key Subjects.

	N	Mean, hrs.	SD
Chemistry	66	11.48	3.73
Physics	66	5.45	4.46
Math	66	9.06	4.33

Most of our students were prepared with the proper prerequisite courses.

The data were first summarized in terms of descriptive statistics and then a series of analyses were conducted. The data for the achievement, motivation, and style variables are summarized in Table 5. The means on the goal variables, the self-efficacy variable and the confidence variables suggest that student motivation related to the class was generally positive (mostly 4.5 to 5.5 out of 6.0 for best). The means on the self-regulation and shallow processing variables show that both types of processing were used. It should be noted, though, that the measure of shallow processing was not sufficiently reliable (reliability coefficient of only 0.49). We also had two learning goals variables, but neither met the standards for reliability, hence, they are not shown.

Table 5
Descriptive Statistics

Variable	Mean	SD	N	Min.	Max.	Reliability Coefficient*
Pretest	67.60	26.13	55	13.00	137.00	
Final Exam	137.34	32.37	53	25.00	182.00	
Percent of Course Points	75.00	13.00	53	33.00	93.00	
Goals – Learning	4.98	.65	62	2.67	6.00	.50
- Future	5.19	.66	60	3.67	6.00	.80
- Performance	2.77	1.33	62	1.00	5.00	.83
- Technology Use	4.88	1.03	62	1.50	6.00	.93
Efficacy: Self-efficacy	4.50	.91	59	2.00	6.00	.83**
- I am confident I have the knowledge of math	5.47	.67	62	3.00	6.00	
- I am confident I have the knowledge of chemistry	5.10	.95	62	2.00	6.00	
- I am confident I have knowledge of physics	4.70	1.28	62	1.00	6.00	
- I am confident I have the ability to use the CDROM work	4.79	1.09	62	2.00	6.00	
- I am confident I have the ability to use the electronic communication	5.15	.93	62	1.00	6.00	
Learning Approaches: Self-regulation	4.28	.83	61	2.17	5.83	.80
- Shallow	4.54	.78	62	2.67	6.00	.49
- Sequential Style	5.11	.64	61	3.67	6.00	.83
- Active Thinking Style	4.59	.85	62	2.33	6.00	.73

*A value over 0.50 reflects internal statistical reliability.
**The 0.83 is a composite of all the efficacy subcategories.

In Table 6 the correlations of the approaches to learning variables with pretest and the two achievement measures (final examination score and total course points) are reported. From Table 6 we can see that among the motivation variables; learning goals, future goals, and self-efficacy have the highest correlations with final exam scores and percentage of course points. The variables asking about confidence in the mathematics and chemistry prerequisites both correlated with percentage of course points. The variable measuring degree of self-regulation was correlated with percentage of course points while the variable measuring degree of shallow engagement with the course material was moderately and positively correlated with both achievement measures.

Table 6
Correlations between Motivation and Style variables with Pretest, Final Examination and Course Points

Variable	Pretest	Final Exam	Percent Of Course Points
Pretest	1.000		
Final Exam	.366**	1.00	
Percent of Course			1.00
Points	.247*		
Goals – Learning	-.099	.279*	.350**
- Future	-.010	.247*	.371**
- Performance	-.152	.102	.021
- Tech in future goals	.206	.146	-.010
Self-efficacy	.267*	.418**	.361**
- I am confident I have knowledge of math	.063	.204	.233*
- I am confident I have the knowledge of chemistry	.098	.173	.336**
- I am confident I have the knowledge of physics	.092	.126	.157
- I am confident I have the ability to use the CDROM work	.286*	.052	.018
- I am confident I have the ability to use the e-communication	.171	.175	.165
Self-regulation	.031	.216	.320*
Shallow	-.070	.248*	.286*
Sequential Style	-.203	.181	.212
Active Thinking	-.276	.052	.211

*Significant at 95% level.
**Significant at 99% level.

Two regression analyses were conducted to examine the extent to which the self-regulation variable, and the motivation and learning style variables might predict final exam scores and percentage of course points earned after variance accounted for by the pretest scores were parceled out. The analyses are summarized in Tables 7 and 8. In the prediction of final exam scores, after pretest scores explained 11% of the variance, self-regulation study method predicted a unique and statistically significant 12% of the variance, the motivation variables predicted another statistically significant 16% of the variance, but the style variables did not add to the prediction of final exam scores.

Table 7
Regression Model Summary for the Prediction of Final Exam Scores

Model		R sq.	Adj. sq.	Std Error	R sq. change
Pretest Alone	.331	.109	.089	30.85	.109
Self-Regulation added	.477	.228	.191	29.07	.118
Goals &Self-Efficacy added	.620	.385	.306	26.93	.157
Learning Styles added	.632	.400	.286	27.30	.015

In the prediction of percentage of course points, after pretest scores explained 5% of the variance, self-regulation predicted a unique and statistically significant 12% of the variance, the motivation variables predicted another statistically significant 15% of the variance. Once again, the style variables did not add to the prediction of percentage of course points. The analysis is summarized in Table 8.

Table 8
Model Summary for the Prediction of Percentage of Course Points

Model	R	R sq.	Adj. sq.	Std Error	R sq. change
Pretest Alone	.228	.052	.030	13.90	.052
Self-Regulation added	.417	.173	.134	13.13	.121
Goals & Self-Efficacy added	.571	.326	.240	12.30	.153
Learning Styles added	.573	.328	.201	12.61	.002

Additional observations come from our surveys about learning and study behavior:

1. Students who reported they learned the module on problem solving strategies did in fact do better on the final examination (26%) and earned a higher percentage of course points (26%).

2. Those who reported reading <u>all</u> of the CDROM earned (33%) more of the total course points.

3. Students who reported learning how to do material and energy balances problems did better on the final examination and course total points (32% and 40%), respectfully.

4. Less successful students skipped studying the fully detailed example problems and practice problems in the CDROM.

V. Improving Method and CDROM

We have continued to improve the primary source of course content, the CDROM, and the format of our method. Student input has been critical in helping us get it right. Table 9 lists some of the likes and dislikes of the students from both semesters. Overwhelmingly, students liked the freedom of self- pacing and the flexibility. The CDROM was also highly favored as a learning tool and as a method to present course content. On a scale of 1 to 10 (best) the students rated the overall quality of the CDROM at a 7 value. There was no correlation of CDROM rating to students' final course grades.

There was no penalty at all for them using or favoring the text over the CDROM. They did lose some agility in test taking because of the many useful tools we had incorporated in the CDROM that could be quickly accessed during test and quizzes.

Table 9 also shows a number of recommendations for improving the CDROM and, of course, removing typos and improved clarity in reading some graphs and charts. Multiple testing on a module is greatly popular with the students, but as mentioned above, this must be changed to better manage faculty time for helping the students who are at greater risk. One interesting note in the table is that the students definitely prefer, by 81%, CD access to course content instead of on line access. They state that mobility and accessibility are the reasons.

Table 9
Likes, Dislikes, Recommendations

Likes	Learning at own pace CDROM , general Retake modules mastery tests Tools menu Animations Example problems Tutoring
Dislikes	CDROM slow loading Some unclear graphs Typos Access to practice problem solutions
Recommendations	CDROM - Add a note pad - Add voice/video - More in the tools menu - Reference links to textbooks - More example problems - Ease of printing screen Format - more lectures - lecture on Wednesdays

In every class there are always students who cannot and/or will not wean themselves from the traditional text. It has become a form of security and legitimacy. Any thing else just does not seem right. We estimate that about 10% of the students in the Fall '00 semester were in this category. One student was rather emphatic about it writing in bold, red letters: "*How about a CD, a book, and MOST IMPORTANTLY, personal instruction from a teacher*?!!." This must really mean, "please lecture to us every period" because the professor was available every Monday and Friday for instruction/tutoring, even if only one student requested it. In total, about a third of the class called for some kind of increase lecturing.

VI. Conclusions

We believe our method combines strengths of the old (lots of student contact and help by the professor) and the new (content delivery in CDROM and WWW format). Students assume responsibility of learning the material in contrast to the "feed me" attitude fostered by lectures format. Students achieve at least the same level of course learning objectives as in the traditional lecture format. There can be a reduction of from 20 to 40% in total time on tasks over a semester for the professor using our method. Time from class lecture presentation and preparation is shifted to tutoring the most needy students. The more talented students may progress as rapidly as they wish. The CD format has greater

possibilities to accommodate more learning styles, although we cannot show this statistically yet.

The best correlations with student success as measured by total course points achieved are those who use a self-regulation study approach, are goals oriented and have a high self-efficacy. Together these can represent 27% of the R^2 in predicting the final course total points. Nothing else is close.

The major change we plan for the next course offering is to reduce the number of times a student may test for modules mastery to no more than two. Of course, we will continue to improve the CDROM for its learn-ability and use-ability. We will continue to seek correlations that can show us: 1) how to change the CDROM to accommodate various learning styles, 2) how to understand student motivation factors for success/failure in this class, and 3) how to direct faculty time where it is most needed, especially for the at risk students.

We welcome your comments, additional information and helpful criticisms. (crynes@ou.edu).

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