

WHY PSI?

HOW TO STOP DEMOTIVATING STUDENTS

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MANY OF YOU reading this article will be teachers who are hoping to improve your effectiveness. You may have even read material on how to motivate students. But a more effective way than trying to motivate them is not to demotivate your students. In order to see how you may be "turning them off" think back to the time you were a student and answer the following questions.

- Have you ever been bored in a class because you understood what the professor was discussing? This could be because he was repeating or elaborating upon an explanation for someone who asked a question or because you had a different background from the average student in the class.

- Have you ever had a struggle to stay awake in a nine o'clock class? Were you worried if you missed that class that you might miss something that might be required later on an exam?

- Have you ever done poorly on an examination even though you knew the material (not just felt you knew it)? Have you ever known everything covered in the course except what was on a test? Have you ever mastered the material by the end of the course but still received less than an "A" because you did poorly on some quizzes and mid-terms? Have you ever had an extremely difficult

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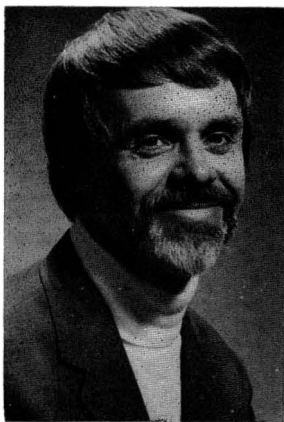
time in a course because you had a poor background at the time you entered the course?

- Have you ever been distracted and lost the thread of a lecture? This could be because there was some commotion, or a particularly intriguing idea which you pursued in your mind while you ignored the lecturer, or you couldn't take notes fast enough.

You can avoid subjecting your students to all these demotivating situations if you are willing to adopt the Personalized System of Instruction (PSI). This is a method of instruction developed in the early 1960's by Fred Keller (hence it is also called the Keller plan) and some of his associates [1]. It is based on positive reinforcement and has been successfully adopted by hundreds of college teachers in numerous different disciplines.

Kulik and Kulik [2] evaluated most of the studies which compared PSI and lecture method. They found 39 studies based on final exam comparisons which seemed to be designed properly and had used control methods to prevent biases. In 34 of these, PSI was shown to be statistically superior. The others gave no statistically significant results but four indicated PSI was better and only one gave lecturing the edge.

These results are especially amazing in the light of a study made by Dubin and Taveggia [3]. They made a comparison of all studies prior to 1968 which attempted to determine if one teaching method was superior to another. They found that whenever there were a number of studies showing one method was best there were almost an equal number of studies which showed that it wasn't. For instance, when the lecture and discussion methods were compared, 51 percent of the time lecturing was superior while the discussion method was shown to be best 49 percent of the time. These are hardly conclusive results.



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The Kuliks also reported that in nine different studies where tests were given some period of time after the students had completed the course, the PSI students' performances were statistically better than those who had had a traditional lecture course. They also found four studies where PSI students performed significantly better in subsequent courses. One additional study of this latter type was statistically inconclusive.

The PSI method replaces the oral communication of a lecture with written instructions. It directs the student to concentrate on the important aspects of the course by providing behavioral objectives. These instructions tell the student precisely what he must know to pass the next test. PSI ends the vaguaries of grading by demanding mastery. It provides immediate, and hopefully, positive feedback by grading a completed exam in the student's presence as soon as he has completed it, and reduces anxiety by exacting no penalty if a student fails an exam. He merely re-takes another over the same material. If the student is ill, emotionally upset, tired or overburdened, he does not need to take a test that day or even that week. He is allowed to proceed at his own pace.

ADOPTING THE METHOD

WHAT MUST YOU DO to adopt this highly successful method? First, a professor must determine the educational objectives of his course.

These state what he expects the students should have achieved when they have completed the course. Then he divides the course into coherent units. The ideal number should be somewhat greater than one unit per week. For each of these units he prepares a written communication which includes an introduction, behavioral objectives, and a procedure for meeting the behavioral objectives. The introduction is a pep talk which should arouse the student's interest and tell why the material is important. The behavioral objectives tell in a specific manner what the student must be able to do to master the unit. For details on how to write these, one can consult Mager's book, *Preparing Instructional Objectives*. All the behavioral objectives given should in some way help the student to reach the educational objectives which the professor originally set.

This procedure gives a method whereby the student may learn the material. It may include doing problems and/or laboratory experiments, reading, reviewing film strips, and completing programmed material. This is merely a method and the student is not required to follow it. He may devise his own way for mastering the material. I have added to my written communications a fourth item, a concept list. This is a list of words or ideas with which I expect the student to be familiar and which I shall be using on tests.

Next, the professor must make up four tests for each unit. These tests should only ask the student to do what has been stated in the be-

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havioral objectives. In five years of teaching this course, only two students on one examination each have ever required more than four tests on a unit. To both of these I administered an oral examination over the unit.

The grading policies in PSI courses vary greatly. My students are told that everyone who masters all the units within the quarter will receive an "A" and all others an "F". Other professors base the grade on the number of units completed. Some use a final exam to determine who should receive "A's" and who should receive "B's" among those who have completed the material. The reason I decided on an "A" or "F"

policy was twofold. First, my course is required, and I feel that all the units are important. If they weren't all important I would eliminate those that weren't and appropriately reduce the number of credit hours. Second, if a student has shown at some time during the quarter that he has mastered everything I asked him to do, he deserves an "A".

CONDUCTING THE COURSE

SINCE LECTURES ARE RARE and the student can proceed at his own pace, the class meeting time has a different purpose than the usual lecture course. At the introductory section of the class the way in which the course is conducted is explained. From then on the scheduled hours are used to answer student questions and for examination taking and grading. There are no attendance requirements. When a student feels he can meet the performance objectives for a unit, he takes an examination. Immediately after he has finished the examination, it is graded in his presence. During the grading he is asked questions by the grader. If he cannot answer these questions, even though he has completed the exam correctly, he is failed. This makes certain the

TABLE 1
Subjects of Units

1. The Reasons for Process Control (1)*
2. Introduction to Laplace Transforms (2, 3)
3. Systems and First Order Responses (5, 6)
4. Combined Systems and Second Order Responses (7, 8)
5. Linearization
6. Modeling
7. Pressure Tank Response and Modeling (Lab)
8. Response of Temperature Measuring Devices (Lab)
9. Controllers, Control Valves, and the Control System (9, 10)
10. Block Diagrams (11, 12)
11. Transient Response of Simple Control Systems (13)
12. Modeling and Response of a Liquid Level System (Lab)
13. Valves and Controllers (Lab)
14. Stability (14)
15. Root Locus Diagrams (15)
16. Introduction to Frequency Response (18)
17. Control System Design by Frequency Response Methods (19)
18. Scale-Up of a Jacketed Heat Exchanger (Lab)
19. Optimum-Control Settings by the Methods of Zeigler-Nichols and Cohen-Coon (Lab)
20. Response of Closed-Loop System (Lab)
21. Simulation of a Closed-Loop System (Lab)
22. Integration of all Material Learned in This Course

*In parenthesis are given the appropriate chapters of the text: Coughanowr, D. R., Koppel, L. B., *Process Systems Analysis and Control*, McGraw-Hill, 1965.

TABLE 2
Student Evaluation of a PSI Course
In Process Dynamics and Control

(59 student responses in five years. 29 students did not complete questionnaire.)

1. Would you rather have had process control taught by the Keller Plan than by the traditional lecture manner? (check one)

YES <u>80%</u>	NO <u>10%</u>	UNSURE <u>10%</u>
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2. Do you feel that you have a good mastery of process control? (check one)

YES <u>72%</u>	NO <u>12%</u>	UNSURE <u>16%</u>
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3. Would you like to have other courses taught using the Keller Plan? (check one)

YES <u>84%</u>	NO <u>2%</u>	UNSURE <u>14%</u>
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student truly understands the material and prevents cheating. If he fails, he is told how he can remedy his deficiency. After an appropriate time, he may then request another exam. To prevent students from taking examinations without proper advance preparation, I inform them that if they fail more than two tests on a given unit, all study problems given in the procedure section of each future unit must be completed and graded before taking an examination covering that unit.

The instructor will need help in grading examinations and answering questions if he has more than 15 students in a lower level introductory course or 10 students for very advanced classes. These can be graduate students, undergraduates who have passed the course, or students who are taking the course. The latter may evaluate examinations over units they have passed.

Choosing these graders is very important. They need to be understanding and encouraging. One year, when it was time to complete our annual faculty evaluation form on the PSI course, the students asked whether I or my proctor was to be rated. I decided both of us should be given separate ratings. I received one of the best ratings for the college; he, one of the worst.

The personality of the instructor and proctor are major factors in the success or failure of a self-paced course. If the person in charge feels the PSI system is a way of reducing his academic load by eliminating lectures and getting others to grade exams, it will fail. If he feels that he will be a stickler for trivial detail—that this is a way to separate those that have it from the dummies, or that he will show the students who knows

most—he will also fail. The instructor must present himself as a facilitator of knowledge. He must appear to be trying to help the student learn, as somebody who is interested in each student and truly wants them to succeed. Arrogance and ego trips have no place in a self-paced course.

PROBLEMS IN PROCRASTINATION

PROBLEMS IN PROCRASTINATION THAT often arise when the PSI method is used are insufficient clarity of examples and explanations in the written material, and the tendency of some students to procrastinate. Any text has its failings and these will become very apparent in a PSI course. To correct these, the instructor must often burn the midnight oil writing supplementary material. His alternative is to spend hours explaining it to every student. Since the background of the students varies from year to year, this is a continuing process.

A number of different things can be done to minimize procrastination. One is to set a time limit for completing the material. I use the last day of final exam week. Another is to conspicuously post a wall chart giving each student's progress. No one likes to be last. A third way to minimize procrastination is to have each student make an appearance at least once a week. It's hard to tell a professor, "I couldn't find time for your course." A fourth is to give occasional stimulating lectures

TABLE 3

Student Response to the Question

1. Did you put more time into this course than most other 6-hour credit (both quarters) courses? (check one)

YES 61% NO 29% UNSURE 10%

which require that a student complete a certain number of units before he can attend. Other gimmicks like giving buttons saying, "I passed Unit 4," where this is a particularly hard unit, can also be used.

The course I teach using PSI is a senior course in Process-Dynamics and Control. It uses *Process Systems Analysis and Control*, by D. Coughanour and L. Koppel as a text and covers essentially the first 19 chapters. The course is divided into 22 units (including eight laboratory units), and has a total of six quarter hours credit spread over two quarters. The titles of the units and the corresponding chapters in the text are given in Table 1.

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TABLE 4

PSI Courses in Chemical Engineering Subjects

Professor	Affiliation	Text Used or Subject
William D. Baasel	Ohio University	<i>Process Systems Analysis and Control</i> Coughanour & Koppel
Karen Cohen	Massachusetts Institute of Technology	Energy Conservation
Ray W. Fahien	University of Florida	Transport Phenomena
David Himmelblau	University of Texas	Optimization
R. Heal Houze	Purdue University	<i>Transfer Operations</i> Greenkorn & Kessler
John Molinder	Harvey Mudd College	<i>Process Systems Analysis and Control</i> Coughanour & Koppel
Noel E. Moore	Rose Hulman Institute of Technology	<i>Process Systems Analysis and Control</i> Coughanour & Koppel
Phillip C. Wankat	Purdue University	<i>Separation Processes</i> C. J. King

This course is an ideal PSI course for two reasons. First, each unit is dependent on a thorough understanding of what has been presented in previous units. If a student does not understand some aspect of the course as it progresses, he will not be able to understand much of what is presented in future units. Second, what is presented initially is not especially exciting to the student because he has difficulty seeing how what he is learning will be useful to him. Because of these two interacting problems, the overall result for a lecture course may be that although the student can manipulate the mathematics adequately enough to pass the course, he often obtains little satisfaction and almost no knowledge. The little he has learned is not integrated into his overall knowledge. It therefore rapidly disinte-

TABLE 5

PSI Seems to Work Well Because It Involves

1. Small Units of Work.
2. Immediate and Specific Feedback About Performance.
3. Requirements of Mastery at Every Step.

grates and is forgotten. The best ways of learning something is to tie it to one's past experience. This is why any instructor should attempt to relate what he is presenting to things in the student's life, or at least to what the student has learned in previous courses. The more relationships of this type the instructor can establish, the better the student will learn the material and the greater will be his retention of the concepts which were presented. This is one of the major purposes of the introduction to each unit. If the introduction is well written, it can help overcome the first problem. The requirement of mastery before the student can progress to the next unit resolves the second. At least he was at one time able to do each important task in each unit. When he needs to use these concepts in later units, he will be able to refresh his memory and not be in the position of having to learn them.

My students' evaluation of the course is given in Table 2. This is a compilation of the responses for five different classes taught in five separate years. In general, they prefer the course, would like more courses taught this way, and felt secure with the subject matter. Various student comments follow:

"Previously I only spent so much time on a course and if I didn't understand something I hoped it wasn't on an exam. I couldn't do that with this course."

"I felt I couldn't do 'A' work, but now I realize I can."
 "It built up my confidence. I felt I could do as well as others."

One criticism I have received from other instructors is that the course requires more time on the part of a student than a traditional lecture course. The students also feel this is true as shown by Table 3. One student, however, placed this in a different context by saying, "This course took no more time than any other course for which I desired and worked for an 'A'." This of course means the average and below average student must put in more time than usual.

Most people teaching PSI courses like them. We encourage those who haven't used the method to try it. In trying the PSI method, one should be careful not to diverge too greatly from the procedure presented in this paper or the first reference. One should be especially sure to include the aspects given in Table 5, for these have been found by studies to be essential to the success of the PSI method.

There are many ChE's teaching modified PSI Courses. At the 1977 Summer School which was sponsored by the ChE Division of ASEE at Snow-

mass, Colorado, those listed in Table 4 indicated they were using the method. □

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