"College teachers usually teach the way they had been taught. We teach our students by lecturing because we got our education this way. However, tradition need not bind us and there are other options available. PSI is one of them."

Six Semesters of PSI: An Evaluation

by

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Introduction

The Personalized System of Instruction (PSI) or Keller Plan was first used for teaching ES 11: Statics of Rigid Bodies to a limited number of students in the U.P. College of Engineering during the first semester of academic year 1979-1980. Reports on the performance of that class were published in the Journal of Engineering Education in Southeast Asia (1) and the Philippine Engineering Journal (2). A few changes were made in the instructional format and in the learning materials after that initial PSI-Statics class. This paper reports the results of the study made on the effectiveness of the Personalized System of Instruction based on its use for six semesters in teaching Statics of Rigid Bodies in U.P.

Description of PSI

The Personalized System of Instruction had its beginnings in 1962 when a group of behavioral psychologists composed of Fred S. Keller, J. Gilmore Sherman, Roberto Azzi and Carolina M. Bori started developing a new method of teaching an introductory course in psychology. This course was first taught using PSI in 1964 at the newly established Department of Psychology of the University of Brasilia. Since then PSI has been used in different universities around the world for teaching courses in such fields as the social sciences, the life sciences, mathematics, the physical sciences, and engineering. The reader is referred to the paper "Good-bye, Teacher . . ." (3) for Fred S. Keller's account of this method of instruction.

In using the Keller Plan for teaching Statics, this writer departed slightly from the original Keller format, principally to take into consideration differences between the demands of an engineering course and a course in psychology. The essence of the Keller Plan, however, remains. What will be described is PSI as it was used for teaching Statics in U.P. up to the second semester of academic year 1981-1982.

The PSI sections of Statics were usually scheduled 2:00 – 4:00 PM, MWF. Although Statics is a 3 – unit course which ordinarily meets three hours a week, students in the PSI sections may attend classes up to a maximum of six hours a week. Attendance, however, is optional and the student is given the freedom to choose not only the day but also the time when he comes to class. Thus, on a given class day, some students may arrive at 2:00 PM or earlier, others might enter the room at 2:30 PM or later, while the rest may not come at all.

The course is divided into 18 units or modules. Units 1 to 15 encompass the core of the course and it is mandatory that the students demonstrate mastery of these units *in sequential order* before they pass the course. Units 16 to 18 are optional and cover materials that are nice to know but are relatively less important than those covered by the earlier units.

A textbook (4) is used in the course. In addition, there is a mimeographed Study Guide for each unit. Each Study Guide contains a list of the objectives of the unit (stated in behavioral terms), a discussion section, a set of study questions and problems, and solutions to selected textbook problems. With the exception of the Study Guide for Unit 1, the Study Guide for a unit is given to a student only after he has demonstrated mastery of the previous unit.

Mastery of a unit is demonstrated through a Readiness Test which a student may take on any class day he chooses. With the exception of the test for Unit 15, the tests are designed in such a way that a student who has prepared well for the lesson can finish each test in about 30 minutes. However, so that the students will not be pressed for time, they are permitted to spend as much as one and one-half hours for each test.

These tests are graded by tutors immediately after the students submit their solutions. The tutors are usually upper classmen in engineering who work as student assistants. The ratio of tutors to number of students is 1:10. A tutor marks the paper of the student "Pass" if *all* questions in the test were answered correctly. The Study Guide for the next unit is then handed out to him. If the student made an error that is fundamental or conceptual in nature, his paper is marked "Recycle". This means that the student has to restudy the unit and come back another day for retesting. There is no limit to the number of re-

testing allowed. In one extreme case, a student had to take ten different tests in one particularly difficult lesson before passing the unit.

A student whose paper is marked "Recycle" is always told by the tutor what is wrong with his solution, why it is wrong, and what is the correct way of doing the problem. There is usually a lively exchange between student and tutor when a paper is marked "Recycle". A student will not accept that his solution is wrong until the tutor convinces him through the logic of his explanation that it is indeed wrong.

On many occasions, a student gets a wrong answer to a problem not because he does not know the concepts but rather because he made some trivial errors in computation. There are problems in Statics whose solutions are quite lengthy and somewhere along the way, the student makes a minor slip that affects his answer. In cases like these where the mistake made is not conceptual in nature, the tutor returns the paper to the student with a notation like, "Review No. 3", if the trivial error was made in question number 3. The student then goes back to his seat and reworks the problem.

Unit 15 serves to integrate the student's knowledge of Units 1 to 14. The test for this unit serves as a sort of final examination and the students are allowed a maximum of two hours to complete the test.

Students in a PSI class usually study in groups of two or three before presenting themselves for testing. They consult each other, teach each other, and argue with one another. When they are not able to agree on something, or if they have difficulty understanding a concept or solving a problem, they consult the tutors or the professor.

The only passing grades given in the PSI — Statics classes during the six semesters covered by this study were 1.0 and 2.0. A grade of 1.0 was given to a student who completed 18 units and a grade of 2.0 to those who completed at least 15 units.* Those who failed to complete 15 units by the last day of class for the semester were given grades of 5.0.

No lectures are given to the class at all for the reason that different students are at different points in the course at any given time. For example, some students may have already completed 16 units by mid-semester whereas others have completed only 10 or 5 or even less units. The student has to depend

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* This was changed to grades of 1.0, 1.5, 2.0, and 2.5 corresponding to completion of 18, 17, 16, and 15 units, respectively, effective the first semester of AY 1982-1983.

heavily on the textbook and the Study Guides for his learning. The tutors and the professor are always available during class periods to give him assistance when needed.

Advantages of PSI

One of the characteristics of the Personalized System of Instruction is the division of the material to be learned into small units each of which can be studied in a relatively short period of time. Cramming, the bane of many a student, does not take place since testing is done after studying a lesson that covers only a few pages of the book. In other words, the prevention of cramming is a built-in feature of the system.

In many courses of study, the student will find it difficult if not impossible to understand the current lesson if he has not learned the previous one. This is more so in subjects like mathematics, physics, and engineering where each new topic builds upon knowledge of principles developed earlier. In the traditional lecture classes, a student is expected to tackle new theories and applications even if he got a grade of zero in the examination on the previous lessons. And so, what usually happens is that the student sits in class bewildered, not understanding what is going on around him. The mastery requirement for advance prevents such a situation from taking place in a PSI class. The student is not forced to tackle a lesson for which he is not prepared. Only after he learns a unit well is he allowed to proceed to the next.

There is a natural variability in the abilities of students. Some are fast learners, others are slow learners. The lecture method requires each member of the class to progress in the course at the same rate. The weak students hopelessly try to proceed at a pace much faster than they can cope with. At the same time, the class slows down the bright students. PSI takes this variability of abilities into consideration and the students move through the course at their chosen pace. Some students finish the course in 9 weeks and receive grades of 1.0, while others may need the whole semester to complete the minimum requirement of 15 units.

Whenever a student fails to pass a readiness test, the tutor always explains the subject matter to him and lets the student go only after he is convinced that the concepts used in that lesson are well understood. Since it is the weaker students who usually fail to pass a test they are the ones who receive the most attention from the tutors, which is as it should be. The bright students receive little assistance as they are generally able to manage on their own. It has also been observed that the weaker students consult the tutors often before they sit down to take a test. There is no fear or inhibition on their part since the tutors are students like themselves. On the other hand, most college teachers

will admit that students who are not doing well rarely approach them for consultation. In fact, some of them even avoid their professors.

The examination hour is usually a tension-filled period in the traditional classes. There are numerous instances when the minds of students black out completely at testing time because of extreme anxiety. The atmosphere is very different during PSI examinations. The students are much more relaxed for two principal reasons. First, they are not under time pressure when answering test questions. They are given as much as 90 minutes for a test that a well-prepared student can finish in 30 minutes. Secondly, if they fail to answer even a single question, this is not taken against them and they know that they have other opportunities to be retested in the same lesson. The knowledge that failure to pass a test does not have an adverse consequence also minimizes the temptation to cheat during examinations.

The testing and grading system under PSI provides the student immediate feedback on how well he is progressing in the course. Only minutes after he submits his paper, the student knows whether or not he passed the test. Being told right then and there that he made it, and being handed the Study Guide for the next higher unit in full view of his classmates are strong positive reinforcements. His behaviour is not much different from that of the pigeon that is rewarded with a pellet each time it performs an assigned task. On the other hand, when told that he recycles a unit, the student usually takes this good-naturedly and just goes about the task of learning to get a "Pass" at retesting time.

One criticism of the lecture method of instruction is that there is little activity on the part of the learner during the lecture period. They just sit passively in the classroom listening to, or pretending to listen to, the professor. PSI forces the student to be actively involved in the learning process. Because of the absence of lectures, the student himself has to dig out the information he needs. He must read and work out exercises regularly. As Tyler (5) said, "The essential feature of any effective means of learning is that the learner carries on the behaviour he is to learn and obtains satisfaction from it. It is not what the teacher does, but what the learner does, that determines learning."

Statistical Data

From the discussion of the advantages of PSI in the preceding section, it is reasonable to expect students taught by this method to generally perform better than students in lecture classes. It will now be determined if statistical data bear this out.

During the six semesters covered by this study, 310 out of the 350 students in the PSI-Statics sections passed the course, i.e., 88.6% passed. On the

other hand, only 950 out of the 1807 who enrolled in the lecture sections of Statics passed. Thus, only 52.6% passed in the lecture classes. A difference of 36% is definitely significant. However, a method of instruction can not be judged superior simply because more students pass. In the first place, students in the PSI and lecture classes were given different tests and were graded differently.

Statics is not a terminal course. It provides the foundation for the study of higher courses in mechanics and design. The next higher courses which have Statics as prerequisite are ES 12: Dynamics of Rigid Bodies and ES 13: Mechanics of Deformable Bodies I. How well the PSI students performed in ES 12 and ES 13 can give an indication of how well the Personalized System of Instruction prepared them for these courses.

A computer program was prepared which traced the progress of students in ES 12 and ES 13. The results are shown in Tables 1 and 2. The term PSI Group refers to those students who passed Statics in a PSI section. The Lecture Group consists of students who passed Statics in a lecture section.

In this paper, the difference between two means is considered significant if the probability of deviation of the sample from the population is less than or equal to 5%, and highly significant if this probability is less than or equal to 1%. The corresponding critical values of the standard normal deviate Z are 1.96 and 2.57, respectively.

In ES 12, the mean grade of the PSI Group is higher than that of the Lecture Group by 0.271. This difference is highly significant (Z = 3.05). The percentage of students who passed ES 12, however, is practically the same for both groups.* In ES 13, the average grade of students in the PSI Group is higher than those in the Lecture Group. However, the difference is not statistically significant (Z = 1.50). The percentage of students who passed ES 13 is almost the same for both groups.

Thus, students who passed statics under PSI did better or at least as well in ES 12 and ES 13 as those who learned Statics in a lecture class. The fact that the students in the Lecture Group went through a more rigid screening process in Statics (only 52.6% passed) did not make them any better prepared for ES 12 and ES 13 than the students in the PSI-Statics classes where 88.6% of the students passed.

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* An average grade lower than 3.00 and a failure rate higher than 50% are atrocious statistics. PSI and other non-traditional methods of instruction are now being tried for teaching ES 12 and ES 13 to remedy this bad situation.

TABLE 1

Comparative Performance in ES 12: Dynamics of Rigid Bodies
AY 1980-1981 and 1981-1982

	PSI Group	Lecture Group
Mean of grades in ES 12	3.088	3.359
Standard deviation	1.100	1.109
No. of students enrolled	283	981
No. of students who passed	135	467
Percentage of students who passed	47.7	47.6
No. of students who failed	58	296
Percentage of students who failed	20.5	30.2
No. of students who dropped	90	218
Percentage of students who dropped	31.8	22.2

TABLE 2

Comparative Performance in ES 13: Mechanics of Deformable Bodies I

	PSI Group	Lecture Group
Mean of grades in ES 13	2.995	3.121
Standard deviation	1.211	1.156
No. of students enrolled	313	1187
No. of students who passed	180	675
Percentage of students who passed	57.5	56.9
No. of students who failed	78	323
Percentage of students who failed	24.9	27.2
No. of students who dropped	55	189
Percentage of students who dropped	17.6	15.9

There is always the possibility that the students in the PSI Group did better because they were really better students to start with. In other words, their performance might be attributable to their inherent talents rather than to the superiority of the Personalized System of Instruction. A comparative study of the academic achievements of both groups prior to their enrollment in Statics must be made before making any conclusion about the effectiveness of PSI.

Before a student is allowed to take Statics, he must first pass Math. 17 (Algebra and Trigonometry), Math. 53 (Elementary Analysis I), Math. 54 (Elementary Analysis II) and Physics 41 (Elementary Physics I). The grades of students in these courses can be used as a measure of their aptitude for quantitative thinking. Those who do well in these courses are predicted to do well in engineering.

Random samples of 50 engineering students each from the PSI and lecture groups who enrolled in ES 12 at least once during academic years 1980-1981 and 1981-1982 were drawn. The means of the grades of these two groups in Math. 17, Math. 53, Math. 54 and Physics 41 were determined and tests were made on the significance of the difference between the means. The results are shown in Table 3. The same procedure was used to produce Table 4 which applies to engineering students who enrolled in ES 13 at least once during academic years 1980-1981 and 1981-1982.

It can be seen from Tables 3 and 4 that, with the exception of the Math. 17 grades of students in ES 13, the average grades of the PSI Group in Mathematics and Physics are lower than those of the Lecture Group. The difference is highly significant in Math. 53 for both ES 12 and ES 13 students. The difference is significant in Physics 41 for studetns enrolled in ES 12.

If performance in mathematics and physics is to be taken as a measure of the scholastic aptitude of engineering students, then Tables 3 and 4 show that students in the Lecture Group have higher aptitudes than students in the PSI Group. And yet, the performance of the PSI Group in ES 12 and ES 13 is better than or at least as good as the performance of the Lecture Group. The Personalized System of Instruction must have had some influence in bringing about an improvement in the performance of the PSI Group.

Comparative Costs

The following features of the Personalized System of Instruction will stand out in the eyes of the cost-conscious university administrator:

1. For a 3-unit course, the professor meets his class six hours, instead of just three hours, a week.

TABLE 3.

Mean Grades of ES 12 Students in Mathematics and Physics

	Math. 17	Math. 53	Math. 54	Physics 41
Grades: PSI Group	1.870	2.430	2.450	2.572
Grades: Lect. Group	1.806	2.052	2.255	2.307
Grade difference	0.064	0.378	0.195	0.265
Z — statistic	0.506	3.076	1.558	2.416

TABLE 4

Mean Grades of ES 13 Students in Mathematics and Physics

	Math. 17	Math. 53	Math. 54	Physics 41
Grades: PSI Group	1.842	2.420	2.415	2.532
Grades: Lect. Group	1.875	2.072	2.255	2.315
Grade difference	- .033	0.348	0.160	0.217
Z — statistic	0.248	2.677	1.230	1.870

2. The services of paid student tutors are used at the rate of one tutor for every ten students enrolled.

3. A substantial amount of printed Study Guides are issued to the students.

4. A PSI class uses a much bigger classroom than a lecture class of the same size. This is because the classroom must have a study area, a tutoring area, and a testing area.

The costs of the above items will now be examined.

The normal size of a lecture class in Statics is 30 students. On the other hand, the PSI-Statics classes during the six semesters covered by this study had an average enrollment of 58.3. Thus, although the professor in a PSI class claims six units of teaching credit because he meets his class six hours a week, the number of his students is almost double that of a lecture class. With class

size taken into consideration, the cost is about the same for both systems of instruction as far as the compensation of the professor is concerned.

The salary of student tutors is an added cost of PSI not present in a lecture class. Each student tutor is paid P400 per semester for 200 hours of tutoring and lesson-preparation time. With six tutors in a PSI class, this is an additional cost of P2400 per semester.

In making a study of different systems of instruction, it is not the absolute cost but rather the cost-effectiveness of the methods which must be compared. A measure of cost-effectiveness is the cost of professor and tutors per student who passes the course. For want of a better term, this will be referred to as "teaching cost".

Let us recall that the passing percentage are 52.6 for lecture and 88.6 for PSI classes, with average enrollments of 30 and 58.3, respectively. These data will be used for computing teaching cost. The value of teaching cost also depends on the salary of the faculty member in charge of the class. In Table 5, the computation of teaching cost is based on the salary and living allowance of faculty members holding the ranks of Instructor I, Assistant Professor I, Associate Professor I, and Professor I.

TABLE 5

Comparative Teaching Costs

Rank of Instructor	Inst. I	Asst. Prof.I	Assoc. Prof. I	Prof. I
Teaching cost for lecture class	P137	P181	P229	P291
Teaching cost for PSI class	P130	P157	P186	P224

It can be seen from Table 5 that, regardless of the rank of the faculty member in-charge, the teaching cost is less when the Personalized System of Instruction is used. The higher the rank of the faculty member, the greater is the saving in teaching cost. Let it be reiterated here that the term "teaching cost" as used in this Table refers to the cost of teacher and tutors per student who passes Statics.

Students pay for the cost of printing the Study Guides (P8.00 for a complete set of 113 pages). This item, therefore, does not involve any additional

expense on the part of the University. The students themselves might not look upon this as an additional expense when they consider the fact that almost half the students in the lecture classes enroll in Statics at least twice (and hence, pay tuition fees at least twice) before they pass it.

It is difficult to put peso figures on the cost of classrooms. There is no doubt, however, that since PSI classes use rooms that are at least twice as big as lecture rooms, the cost of classrooms is higher for PSI. One factor, however, must be taken into consideration in assessing this particular cost. Forty seven per cent of the students in the lecture classes will repeat the course and come back another semester to occupy classroom space again for the same course. In contrast to this, the University needs to provide far less classroom space for repeaters in PSI classes since there are very few of them, i.e., only 11.4% of PSI students.

Conclusion

Many researches have already been undertaken to assess the effectiveness of the Personalized System of Instruction. Taveggia [6] summarized the results of 14 separate studies on PSI carried out from 1967 to 1974. The paper of Kulik, Kulik, and Cohen [7] synthesized 75 comparative studies of PSI. These investigations are practically unanimous in the conclusion that PSI is superior to conventional teaching methods for teaching a variety of courses to students with a wide spectrum of abilities. To quote from Kulik et al, "PSI turned out to be equally effective in introductory and non-introductory courses, and PSI superiority was equally clear at major research universities, less prominent research universities, doctorate-granting universities, comprehensive colleges, liberal arts colleges, and community colleges or special institutions."

The results so far obtained in the limited use of PSI in the U.P. College of Engineering have been very encouraging. There is a dramatic increase in the percentage of students who pass the course where the Personalized System of Instruction is used. Not only that, the students who passed Statics under PSI did better or at least as well as their counterparts in lecture classes in two courses (ES 12 and ES 13) which had Statics as a vital prerequisite. This despite the fact that the average ability of the students who enrolled in the PSI Sections (as judged from their grades in mathematics and physics) was longer than that of the lecture students.

PSI works, and the reason is, the design of this system of instruction is based on what scientists have learned about the process of learning. The psychologists who originated PSI made full use of their knowledge of learning

theories in structuring the elements which make up the Personalized Systems of Instruction.

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Acknowledgement.

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