The Keller Plan in Science Teaching

An individually paced, student-tutored, and mastery-oriented instructional method is evaluated.

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The Keller plan or Personalized System of Instruction (PSI) is an individually paced, mastery-oriented teaching method that has had a significant impact on college-level science education in the past few years.

This method of instruction has a short history but a longer past. Its history goes back to 1964 when psychologist Fred Keller and his colleagues offered their first personalized course at the University of Brasilia. But the Keller plan is part of a much longer tradition of experiments in individualized instruction. As early as 1919, the public schools of Winnetka, Illinois, began using an instructional method that was very similar to the Keller plan in its main features. The Winnetka plan too involved self-pacing and repeated testing of students until mastery was demonstrated. In the years following the Winnetka experiment, other programs of individualized instruction were developed in scattered classrooms and schools in the United States and abroad. But it was not until the early 1960's that the concept of individualized instruction developed firm roots. R. Glaser's system of individually prescribed instruction, J. Flanagan's Project Plan, and S. Postlethwait's audiotutorial approach date from these years (*1*). But for the most part, the early experiments in individualized instruction were directed toward secondary and elementary schools. Keller and his colleagues were among the first to apply the concepts of individualized instruction systematically in higher education.

With the publication of Keller's paper "Good-bye, Teacher!" in 1968 (*2*), the Keller plan achieved national recognition, and many college instructors began experiments using Keller's approach. Hess's comprehensive survey in November of 1972 (*3*) located 877 PSI courses in psychology alone, probably about half the total number of science courses now offered in the format. There are signs that the future will bring even wider use of the plan. Commercial materials are becoming available for implementing courses in PSI format, a clearinghouse for uncopyrighted material has been established, and a master file of Keller courses is in the works.

The Keller plan has also been extensively studied in the past 5 years. Hess's bibliography (*3*) lists 261 published and unpublished papers. We reviewed the evaluative research reported in these papers to assess the Keller plan's contribution to higher education and its potential for the future (*4*).

Basic Features of the Keller Plan

In his 1968 paper (*2*), Keller described the five features of his instructional plan that distinguish it from conventional teaching procedures. A Keller course is (i) an individually paced, (ii) mastery-oriented, (iii) student-tutored course, which (iv) uses printed study guides for communication of information, and (v) includes a few lectures for stimulation and motivation of students.

A student beginning a Keller course finds that the course work is divided into topics or units. In a simple case, the content of the units may correspond to chapters of the course text. At the start of a course, the student receives a printed study guide to direct his work on the first unit. Although study guides vary, a typical one introduces the unit, states objectives, suggests study procedures, and lists study questions. The student may work anywhere —including the classroom—to achieve the objectives outlined in the study guide.

Before moving on to the second unit in the sequence, the student must demonstrate his mastery of the first by perfect or near-perfect performance on a short examination. He is examined on the unit only when he feels adequately prepared, and he is not penalized for failure to pass a first, second, or later examination. When the student demonstrates mastery of the first unit, he is given the study guide for the next unit. He thus moves through the course at his own pace. He may meet all course requirements before the term is half through or he may require more than a term for completing the course.

The staff for implementing the Keller plan includes the instructor and undergraduate tutors. The instructor selects and organizes material used in the course, usually writes study guides, and constructs examinations for the course. He gives fewer lectures or demonstrations than in a conventional course (perhaps six during a semester), and these lectures are not compulsory and no examinations are based on them. The tutor evaluates readiness tests as satisfactory or unsatisfactory. Since he has been chosen for his mastery of the course content, the tutor can prescribe remedial steps for students who encounter difficulties with the course material. The tutor also offers support and encouragement for beginning students.

Some college instructors have offered courses duplicating Keller's in all essential respects, and some have modified Keller's design slightly to serve local needs. Both faithful reproductions and near copies of Keller's course are considered in this article. Programmed or individualized courses that lack such essential features of the method as self-pacing and mastery orientation will not be considered (*5*).

Student Ratings of Keller Courses

In his initial description of the plan, Keller (*2*) reported that students rate personalized courses as much more enjoyable than conventionally taught courses. All research papers since Keller's confirm that students are highly pleased with this way of teaching and

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learning (Table 1). Several kinds of evidence have been used to make this point.

Some investigators have solicited open-ended course evaluations from students and classified such comments as "negative" or "positive." Gallup (*6*) reported that 98 percent of the students made favorable comments about his personalized course in introductory psychology, and only 2 percent commented unfavorably on some aspect of the course. Green (*7*) stated that only 2 out of 50 students commented unfavorably on his Kellerized course in physics.

Another common strategy is to have students compare their Keller course to the typical course that they have taken in college. Hoberock *et al.* (*8*) summarized the results of four applications of the method at the College of Engineering of the University of Texas at Austin. In a course in nuclear engineering, 72 percent considered PSI better than the lecture method while only 6 percent considered the lecture method superior. In a course in electrical engineering, 91 percent preferred PSI to the lecture method; in mechanical engineering, 64 percent preferred PSI; and, finally, in a course in operations research, 59 percent preferred PSI. Other investigators (*6, 9, 10*) have used this method with favorable results.

The most convincing of all the student-rating studies are those that compare a PSI course with a conventionally taught course. An excellent study of this sort is that of McMichael and Corey (*11*). In this study, the numbers of students are large; there are several conventionally taught sections for comparison, each given by a different instructor; and dropout rates for the three sections are comparable (and low) and do not complicate the comparison. On a scale running from 0 (extremely poor) to 10 (extremely good), the Keller section received a modal rating of 10; the other three sections received modal ratings of 5, 8, and 8. The mean ratings were 9 for the Keller section and 6, 7, and 5 for the control sections. The experimental group mean was higher than each of the control group means at a high level of significance. Other studies using control groups also report significantly higher evaluations for Keller sections (*12–15*). The attractiveness of the plan to students therefore seems no longer a matter of controversy.

Outstanding Keller Course Features

Several investigators have tried to specify the features of Keller courses which contribute most to these favorable ratings. Green (*7*) categorized student comments about Keller courses, and reported that the feature most often praised is the freedom of pace. Other features frequently praised by Green's students were freedom to study when and where one wishes, tutors, mastery criterion for advancement, and immediate feedback. Nelson and Scott (*16*) had students rank 12 features of a self-paced course in educational psychology in terms of importance to enjoyment of the course. Most important were self-pacing (first), interactions with teaching assistant and interactions with the instructor (tied for second and third), small steps (fourth), and discussions (fifth). In a modified Keller course in psychological statistics (in which there were no undergraduate tutors), Myers (*17*) also found that self-pacing was the feature rated most highly by the students. To students, self-pacing and personalized interactions seem to be the most attractive feature of the Keller plan.

Faculty users sometimes describe the Keller plan as a programmed approach to instruction, and stress its link to B. F. Skinner's work on behavioral control and technology. Students, however, see the Keller plan as neither controlling nor technocratic. Instead, they like its freedom, self-determination, and personal interaction. In their appreciation of the Keller plan, faculty members may be Skinnerian, but students apparently are not.

Other Expressions of Evaluation

The picture of the Keller plan that has been drawn so far is based on student self-report. Are such reports reliable or are they just "talk," polite and inconsequential amenities made at the finish of experimental courses? Some investigators have reported on decisions and commitments made by students in Keller courses, and these are a valuable supplement to the verbal reports. Withdrawals from PSI courses, election of further courses in the PSI format, and changes in academic major have been considered.

In his 1968 paper (*2*), Keller presented grade distributions from two classes at Arizona State University. The withdrawal rate from each of these classes was about 20 percent. While no control data were presented from comparable courses given by traditional methods, withdrawal rates of 20 percent seem high. In a later paper, Sheppard and MacDermot (*13*) reported a withdrawal rate of 17 percent from the Keller section of an introductory psychology course, which was higher than the rate in traditional sections (6 percent). Born (*18*) also presented withdrawal rates (14, 25, and 14 percent) from three Keller courses and from three conventional courses (5, 6, and 5 percent) at the University of Utah. Withdrawals from the PSI courses are three to four times higher than those for the conventional courses. The high rate of withdrawal seems to belie the favorable ratings.

But this is not the whole story. The withdrawal rate from McMichael and Corey's (*11*) introductory psychology course (12 percent) was lower, if anything, than the withdrawal rates in conventional sections of the course (16, 14, and 9 percent). In advanced engineering courses at the University of Texas, described by Hoberock *et al.* (*8*), withdrawal rates were also not high—between 5 and 10 percent. Of 38 students in Myers' (*17*) introductory statistics course at the University of Wisconsin, none withdrew or received a grade of incomplete. Friedman (*19*) at MIT reports being discouraged by a withdrawal rate of 24 percent until discovering that the withdrawal rate from the comparable lecture section was considerably higher. Taking all the literature into account, one finds that the Keller plan is sometimes but not always associated with a high rate of withdrawal. In some applications of the plan, the rate of withdrawal is quite low. The generally favorable ratings are not merely a function of dropout by dissatisfied students—highly favorable ratings have been reported in courses for which dropout rates are high, medium, and low.

Born's (*18*) careful analysis of the dropout question suggests that Keller courses have high withdrawal rates when they are arranged so that students delay starting the course, put off taking tests, and generally procrastinate. Several procedures have been devised to prevent procrastination. Green (*7*) found that procrastination and withdrawal can be prevented by (i) publishing a recommended schedule of dates for passing units which will yield

a steady rate of work; (ii) making admittance to "fun" lectures contingent on having passed units; and (iii) offering early final exams for students finishing the units early. Nelson and Scott (*16*) found that doubling the number of units in a self-paced course (and thus cutting the size of the units in half) influences the rate of student progress. Small units lead to more rapid and consistent rates of progress. A number of other suggestions have been made for handling the vexing problem of high withdrawals.

Other behavioral indicators of acceptance of the plan have been examined less carefully than withdrawal rates. Green (*7*) reported that 90 percent of the students who have taken Keller courses take further courses by the Keller plan when that option is available to them. Gallup (*20*) reported that he has been forced to limit the size of his introductory course since he offered it in the PSI format, and that the number of psychology majors has increased markedly since the introductory course was given in this way. These questions have not been systematically explored.

Content Learning in Keller Courses

In the first courses offered by the Keller plan, students seemed to learn course materials remarkably well. About 50 percent of the students received A's as final grades. In one of Keller's courses at Arizona State University, students took a midterm examination comparable to the one used in a conventional course at an "Ivy League college." There is no question that the Arizona State scores on the midterm were higher. But Keller was aware of the limits of such comparisons, and warned that "their importance should not be overemphasized" (*2*, p. 86). In interpreting the results of such comparisons, several factors should be kept in mind.

Grades in Keller courses are assigned on a different basis from grades in lecture courses. Anywhere from 50 to 100 percent of the student's grade in a Keller course comes from the number of repeatable examinations passed on short units of content. In lecture courses, grades are most often assigned on the basis of quality of performance on midterms, finals, and term papers. Differences in grade distributions for the two types of classes may therefore reflect either the differences in grading method or differences in amount of content learned. There is complete confounding.

Studies comparing examination scores of students in Keller and lecture courses offer more promise, but the ideal experimental design is easier to imagine than to achieve. A number of methodological pitfalls must be avoided. The comparison cited by Keller illustrates some of the difficulties.

1) Are the comparison groups equivalent at the start of the experiment? In an ideal experiment, the experimental and control groups are random samples from the same population. No one would claim that students at Arizona State University and an "Ivy League college" meet this requirement of experimental design. In Green's report (*21*), a great deal of self-selection and instructor selection of students makes it highly unlikely that the two comparison groups are equivalent at the outset.

2) Is the performance of each subject in the comparison groups taken

Table 1. Student ratings of Keller courses.

Reference	Course or courses	Results and comments
	Studies without a control group	
Gallup (*6*)	Introductory psychology	Favorable comments about course from 98 percent of students; no negative comments about course as a whole
Born and Herbert (*34*)	Introductory psychology	Only 7 of 145 students would not recommend course to other students
Flammer (*10*)	Fluid mechanics	Preference for taking course by PSI stated by 93 percent of students
Green (*7*)	Freshman physics	Only 2 of 50 students commented unfavorably about course
Hoberock *et al.* (*8*)	Nuclear, mechanical, electrical, and operations research engineering	In four courses, PSI was considered better than the lecture method by 72, 64, 91, and 59 percent of students
Knightly and Sayre (*9*)	Library science	Self-paced mode of instruction considered better than lecture method by 100 percent of students; course rated as "one of the best" or "above average" by 93 percent
Walen (*35*)	Abnormal psychology	Mean rating of various aspects of course ranged from 7.9 to 9.0 on a 10-point scale
Philipas and Sommerfeldt (*28*)	General physics	Keller plan preferred to lectures by 90 percent of students.
Powers (*36*)	Introductory psychology	PSI course rated more interesting and more informative than other courses by most students
Roth (*23*)	Digital systems engineering	PSI rated better than lecture method by 90 percent of students the first time course was given, and by 79 percent the fifth time course was given
Simmons (*26*)	Introductory physics	PSI rated better than lecture system by 97 percent of students; course rated as above average or higher by 93 percent
	Studies comparing Keller and control sections	
McMichael and Corey (*11*)	Introductory psychology	Ratings in Keller section were significantly higher than in each of three control groups ($P < .0001$)
Sheppard and MacDermot (*13*)	Introductory psychology	Student satisfaction in the PSI section was significantly higher than in the conventional section ($P < .01$)
Born *et al.* (*12*)	Psychology of learning	Eighty-five percent of students in PSI class would recommend it as compared to only 50 percent of lecture students
Morris and Kimbrell (*15*)	Introductory psychology	Ratings of overall quality were significantly higher in Keller section than in control section ($P < .001$)
Witters and Kent (*24*)	General psychology, cultural anthropology	In psychology, Keller-like section rated course as significantly more enjoyable than control section ($P < .05$); in anthropology, ratings from Keller section were higher, but not significantly so

into account? Keller mentioned that the unannounced midterm was taken by 66 Arizona State University students, but did not say what percentage of students in the course this represents (the only class size mentioned in the article for an Arizona State course is 208). If the midterm was given on a single day, only a fraction of the students in the Keller course would be in attendance, and those most likely to be present would be the better students. Other studies comparing final exam performance are ambiguous in their results because of differential dropout from Keller and conventional courses. In Sheppard and MacDermot's study (*13*), the performance of the experimental section was superior to that of a control section on both an essay final and a multiple-choice final examination. But the withdrawal rate from the experimental section was three times that of the control section. The Born *et al.* study (*12*) suffers the same drawback.

3) Are students "taught the test" in the Keller section? In many Keller courses, students are told what they are to learn in clearly specified objectives, and are repeatedly tested for their mastery of these objectives in unit tests. Final examinations necessarily cover the same ground. This is quite different from the conventional teacher's practice of not "giving away" the content of the final. In Keller's course, the midterm examination was constructed by the Ivy League instructor, but 13 percent of the items had to be deleted for the Arizona State students "on the grounds of differential coverage." To some degree, all comparisons of Keller and conventional courses are clouded by the shadow of this difference in outlook toward testing.

Table 2 presents results from 15 studies in which examination results in Keller and conventional courses were compared. Of the 15 studies, superior performance for the Keller section was reported in 11, and no significant difference between the two kinds of class was found in four. At least five of the completely reported studies are relatively free of difficulties in design and analysis, and in each of these the performance of the Keller section was superior to that of the conventional section. These studies will be considered here.

In McMichael and Corey's study (*11*), a final examination composed of items that did not overlap with unit tests was administered to students in one experimental and three control sections of a course in introductory psychology. Sections were large (about 200 per section), and students registered for these sections without prior knowledge of the teaching method to be used. Withdrawal rates for the four sections were nearly equal. Mean scores (out of 50 possible points) for the various groups were 40 for the experimental section and 35, 34, and 34 for each of the control sections. The experimental group performance exceeded that of each of the control groups at a high level of statistical significance. In a related study, Corey *et al.* (*22*) reported on the long-term retention of material for this course. Their data indicate that the initial superiority of students in the experimental section was maintained for a long period. Students in the Keller section remembered as much of the course material 10 months after the course ended as control students knew at the time of the original final exam.

Roth's report (*23*) on the continuing effectiveness of his personalized course in digital systems engineering is also valuable. In the fifth semester that Roth offered the course, he compared final examination performance of his PSI section with performance in a concurrrently offered lecture section. Students were assigned to lecture and PSI sections according to time preference, and students in both sections were comparable in grade-point average. The two sections used the same text and study

Table 2. Comparisons of examination performance in Keller and conventional courses.

Reference	Course or courses	Results and comments
Gallup (*6*)	Introductory psychology	PSI exam mean significantly higher, variance significantly smaller than for lecture group, but not all PSI students took final exam
Green (*21*)	Freshman physics	No difference between Keller and lecture sections on midterm exam; considerable selection for PSI section
McMichael and Corey (*11*)	Introductory psychology	Keller section mean significantly higher ($P < .0001$) than each of three control group means
Moore *et al.* (*14*)	Biology, psychology	PSI groups performed significantly better than control groups on final exams ($P < .05$)
Sheppard and MacDermot (*13*)	Introductory psychology	PSI group performed significantly better than control group on both objective and essay final exams; differential dropout from two groups
Billings (*29*)	Principles of economics	Gain in score on tests given before and after course was greater for PSI group than national norms would suggest
Born *et al.* (*33*)	Introductory psychology	PSI group scores significantly higher than those of control group on final exam ($P < .05$); brief report
Born *et al.* (*12*)	Psychology of learning	Combined final and midterm scores of lecture section significantly lower ($P < .05$) than those for each of the other sections (Keller, modified Keller, and rotating); differential dropout from sections
Hapkiewicz (*32*)	Graduate educational psychology	No difference between modified Keller and lecture sections on final exam results; unit mastery not required for modified Keller group
Morris and Kimbrell (*15*)	Introductory psychology	Keller section scores significantly higher than those of control on final exam ($P < .05$)
Muir (*37*)	Experimental psychology	No difference between PSI and control class in test performance; small, unmatched groups
Philippas and Sommerfeldt (*28*)	General physics	No difference between Keller and lecture sections on final exam results; higher withdrawal from Keller section
Protopapas (*38*)	Biology	PSI grade distribution on final exams considerably higher than lecture distribution; very brief report
Roth (*23*)	Digital systems engineering	PSI group scores significantly higher than those of lecture group on final exam
Witters and Kent (*24*)	General psychology, cultural anthropology	Keller-like groups performed significantly better than controls on exams in each of two semesters ($P < .05$)

guides. On the final exam, prepared jointly by the PSI and lecture instructors, performance of the PSI students was significantly and considerably higher than that of students in the lecture section.

Other excellent studies are those of Witters and Kent (*24*) and Morris and Kimbrell (*15*). In these studies, the Keller sections clearly did better than lecture sections on hourly and final exams. Neither of these studies is plagued by problems of initial differences between experimental and control groups or overlap of items on unit tests and other examinations. There were apparently no withdrawals from courses described by Witters and Kent, and the withdrawal problem is handled by the appropriate statistics in the study by Morris and Kimbrell.

On the basis of present evidence, it can be concluded that content learning (as measured by final examinations) is adequate in Keller courses. In published studies, content learning under the Keller plan always equals, and most often exceeds, content learning under the lecture method.

Other Indicators of Content Learning

Whatever final examinations show, students in Keller sections almost invariably feel that they learn more from personalized instruction than from the lecture technique. A typical report is that of Lanson and Benassi (*25*). They reported that 87 percent of the students in a course on human behavior analysis felt that they learned more through PSI than they would have through a lecture course, 13 percent felt that the amount was equal, and none felt that they had learned less. Similar results are reported by Simmons (*26*), Dealy *et al.* (*27*), Gallup (*6*), Philipas and Sommerfeldt (*28*), Billings (*29*), and Moore *et al.* (*14*).

Students also nearly always report putting a great deal of time and effort into Keller courses. Usually the commitment is considered greater than for comparable lecture courses. A course in nuclear engineering described by Koen (*30*) is typical in this respect. Nearly 90 percent of the students felt that this PSI course required more effort than a comparable lecture course, while the remaining students felt that about the same amount of effort was required. No one felt that the amount of time required in the PSI section was less. Reports of other investigators are similar (*6, 8, 16, 26, 28, 29, 31, 32*).

Several investigators have reported on the amount of study time required for Keller and lecture sections of courses. Students in Roth's (*23*) PSI section of digital systems reported spending an average of 8.1 hours per week on the course, whereas students in a concurrently offered lecture section reported 6.7 hours per week. Born *et al.* (*33*) put all study materials for a course in introductory psychology into a single library so that students' study behavior could be monitored. These investigators found large and statistically reliable differences in the total study time of students in the Keller and lecture sections of the course. The average student in the lecture section studied 30.2 hours during the term, while the average PSI student spent 45.5 hours in study—a 50 percent increase in total study time.

Summary

A review of evaluative research on the Keller plan establishes the following points:

1) The Keller plan is an attractive teaching method to most students. In every published report, students rate the Keller plan much more favorably than teaching by lecture.

2) Self-pacing and interaction with tutors seem to be the features of the Keller courses most favored by students.

3) Several investigators report higher-than-average withdrawal rates for their Keller sections. The conditions that influence withdrawal and procrastination in Keller courses have been studied, and it seems possible to control procrastination and withdrawal through course design.

4) Content learning (as measured by final examinations) is adequate in Keller courses. In the published studies, final examination performance in Keller sections always equals, and usually exceeds, performance in lecture sessions.

5) Students almost invariably report that they learn more in PSI than in lecture courses, and also nearly always report putting more time and effort into the Keller courses.

References and Notes

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