ECONOMIC EDUCATION

TIPS and Technical Change in Classroom Instruction

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This paper presents some research results on the efficiency of a teaching technique (*TIPS*) I have used in the Principles of Economics course at the University of Wisconsin–Madison. My presentation will be extremely selective; only the results of five out of some ten different output measures are reported. I shall argue that *TIPS* represents an improvement over the commonly employed lecture-discussion classroom technology. The model I use to evaluate the efficiency of *TIPS* is broader than that usually used in educational research, since it takes into account not only the total magnitude of the benefits and costs, but also their distribution.

TIPS

TIPS (Teaching Information and Processing System) is a testing and evaluation system which provides the capability of increasing the level of individualized instruction in the classroom (Kelley, 1968, 1970). *TIPS* enables the instructor to prepare, administer and process short multiple-choice "surveys" on a regular basis throughout the semester. Based on the results of each survey and on instructions or "decision rules" provided by the professor, a series of instructional reports are prepared and printed by data processing equipment. Under normal circumstances the surveys are given once every week and require ten to fifteen minutes of class time. To date the surveys have not been used for grading; they have been administered to provide interim information used to diagnose student difficulties and to prescribe remedies before major examinations take place.

Three major sets of instructional reports are generated by *TIPS*. A *Student Report*, prepared for each student in the class, is available three to four hours after the student leaves the classroom. This report provides individualized assignments for each student based on his measured proficiency on the various concepts covered on the *TIPS* survey. A student performing well on one concept may receive an enrichment and/or optional assignment; on another concept, where deficiency is revealed, he may receive a lower-level required assignment. Assignments may also be based on the student's learning skills, e.g., his mathematical versus his verbal ability. The *TIPS* survey results permit identifying well before formal examinations those students who are failing the course; individual tutorials and compensatory instruction may then be arranged. Superior stu-

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dents may be provided the option of writing papers or engaging in research in lieu of taking the exam.

Summary reports are prepared for both the professor (covering class performance) and the teaching assistant (covering the results of each *TA*'s sections). These reports provide the feedback required by the instructor to modify his class assignments and presentations in response to revealed deficiencies and strengths. The *TA* reports also provide a list of assignments required of each student, together with lists of students who, for example, are required to establish tutorials or who have been provided the option of writing papers and engaging in term-paper research.

TIPS employs some of the oldest principles of instruction but uses modern technology to provide each student a course of instruction appropriate to his needs. The degree of individualized instruction facilitated by *TIPS* is largely invariant to class size. This approach is applicable to a wide range of disciplines where course objectives can in large part be measured by well-designed objective-type questions. The system is designed to attenuate instructional problems inherent in higher education where expanding enrollments and rising costs are accompanied by large class sizes and where student abilities and interests span a wide spectrum.

A Model of Educational Evaluation

The model of educational evaluation employed below emphasizes the *distribution*, as well as the total magnitude, of benefits and costs associated with alternative instructional approaches (Hansen *et al.*). The pervasive failure to consider distributional issues in educational evaluation is tantamount to assuming either that students are a homogeneous group—each student receives the same amount of outputs and sustains the same amount of costs, and the outputs and costs are valued equally for each student—or that students should be treated as if they were a homogeneous group. Two implications of these observations relate to the appraisal of the literature evaluating educational technology. First, there is an abundance of studies which fail to identify a statistically significant impact on student performance of alternative educational approaches; this may, as McKeachie has observed, result from the fact that "methods optimal for some students are detrimental to the achievement of others" (p. 1157). Second, if students do benefit differentially from alternative teaching techniques, the statistical models which omit these distributional effects are misspecified; they produce statistically biased and typically uninterpretable results.

The Experimental Evaluation of TIPS

In the fall of 1968 *TIPS* was utilized in an experiment in the Principles of Economics course at the University of Wisconsin–Madison. The objective was to assess the impact of *TIPS* on student achievement, student attitudes toward the course and *TIPS*, and student retention of economic principles (measured one year later). Students in the experimental group employed *TIPS* during the first eight weeks of the course. Students in the control group were taught using a lecture-T. A.-homework assignment format thought representative of that widely employed in the principles course. The control and experimental student groups met with their professor three times a week; the fourth session, a discussion led by a graduate teaching assistant, met in smaller groups of fifteen to twenty-five students. The *total* amount of homework assignments in the two groups was approximately the same. In the control group all students received an identical "average" assignment. In the experimental group the students in difficulty received larger and lower-level assignments; those demonstrating proficiency were given optional, ungraded assignments.

The control and experimental lectures, each comprising about 250 students, met with the same instructor at contiguous lecture hours in different buildings. In both groups students received almost identical lectures. *TA*'s were randomly selected from the Departmental "pool" and were assigned to one of the two lectures without bias. Identical text materials were required. Subsequent analysis reveals that a minimum of student interaction between the two groups occurred; furthermore, statistical tests show that the two lecture groups possessed a statistically identical distribution of attributes: aptitude, prior academic achievement, sex, academic major, class, and mathematics background. The "Hawthorne effect," likely present, was attenuated by the procedure of briefing students in the *TIPS* class with the use of a nonpromotional, printed document describing the system and the experiment. This avoided any tendency toward overemphasis of the experiment by the instructor.

Considerable care was taken to obtain output measures which were valid and unbiased. A two-hour mid-term examination contained twenty multiple-choice questions drawn from those provided in the instructor's manual to the text; none of the questions had appeared on *TIPS* surveys. The student also answered five short-answer questions of an applied-problem type, and had a choice of one of two long essays. The short-answer questions and essays were equally divided between questions submitted by *TA*'s in the two lectures. Students in both lectures were administered identical examinations at the same hour (different buildings). Elaborate precautions were taken to ensure objectivity of grading: multiple choice questions were machine graded; the remaining portions of the tests were anonymized by removing student names and assigning a numerical code for subsequent reassembly. All responses to a particular question by students from both lectures were graded by a single *TA*. Undoubtedly the grading possessed significant variance in terms of accuracy; we assert, however, that there was no bias which would preclude an objective appraisal of the impact of *TIPS*.

Impact of TIPS on Student Achievement

Space precludes the presentation of the theoretical model underlying the analysis, the results for each of the output measures, a discussion of the estimation format employed, and a defense and interpretation of each variable included in the regression. The results presented in equation (1) for the aggregate score from the first midterm examination are representative of the output measures over that portion of the course when *TIPS* was used. Least squares regression procedures were employed; t statistics are in parentheses.

$$
\begin{aligned}
(1)\quad O = {} & \underset{(5.18)}{18.35} + \underset{(5.98)}{.17}\, ACTSAT + \underset{(2.85)}{.08}\, LogHSP + \underset{(3.08)}{3.23}\, SOPH + \underset{(2.59)}{3.95}\, UPPER + \underset{(.28)}{.31}\, MATH \\
& + \underset{(.67)}{.94}\, PSENG + \underset{(1.63)}{1.84}\, BUS + \underset{(.62)}{1.16}\, ECON + \underset{(3.11)}{.71}\, COMASGN + \underset{(2.98)}{.09}\, PCTSECT \\
& + \underset{(2.17)}{1.56}\, ASNDONE - \underset{(-1.66)}{.30}\, LogASNDONE \cdot ACTSAT + \underset{(3.26)}{38.35}\, TIPS - \underset{(-2.15)}{3.96}\, ASNDONE \cdot TIPS \\
& + \underset{(1.77)}{.82}\, ASNDONE \cdot LogACTSAT \cdot TIPS - \underset{(-2.20)}{6.39}\, LogACTSAT \cdot TIPS \qquad \bar{O} = 52.09 \quad r^2 = .34
\end{aligned}
$$

Student achievement was positively and significantly related to the number of homework assignments completed (*ASNDONE*), the percentage of sections attended (*PCTSECT*), whether the student was a sophomore or an upperclassman (*SOPH*, *UPPER*), his *ACT* or *SAT* score, his graduating high school percentile ranking (*HSP*), the difference between the number of his required assignments and those handed in (*COMASGN*—a measure of commitment?), and whether he was in the *TIPS* class. Neither knowledge of calculus (*MATH*) nor major (*PSENG*, *BUS*, *ECON*—physical science or engineering, business, economics) contributed significantly to examination achievement.

An interpretation of the results in (1) is facilitated by comparing the aggregate performance of four "representative" students. Table 1 presents the predicted score of four students and the percentage contribution to that score due to the several independent variables. Charles Kinbote and Jack Gradus are "average" students in the *TIPS* and control groups, respectively; they are "twins" in all respects except *TIPS*. John Shade is a relatively low achiever in the *TIPS* class; Sybil Swallow is relatively bright.

As in most studies, prior aptitude and achievement constituted the most important independent variables, accounting for around 25–35 percent of the explained variance. Section attendance counts significantly and positively, although these results do not necessarily measure the absolute contribution of the *TA*'s or sections (i.e., there was no control), but rather the impact of differential section attendance, a measure which could be a proxy for student attributes such as study discipline, interest in the course, and so forth.

Homework assignments were most beneficial to the relatively slow student as measured by *ACT-SAT* scores; they were of little significance for the bright student. This result illustrates one way in which *TIPS* could possibly increase the efficiency in the use of instructional inputs and, in this case, the student's time. Since bright students in the *TIPS* class received very few required assignments, *TIPS* was likely instrumental in increasing the productivity of instructional resources. Not only did bright students "save" ten to fifteen hours per semester by not working assignments of low productivity, but *TA*'s spent no time grading and recording the results. Instructional resources were instead shifted toward the low-achieving student, where the relative productivity of the homework-assignment technique appears to be high.

The contribution of *TIPS* to student examination performance was greatest for the relatively low-achieving student (19.5 percent), falling to 13.3 percent for his brighter classmate. The impact of *TIPS* occurs not only through individualized homework assignments, but also through

TABLE 1—PERCENTAGE CONTRIBUTION OF EACH FACTOR TO THE PERFORMANCE OF INDIVIDUAL STUDENTS ON THE FIRST MIDTERM EXAM

Name of Student	Predicted Score	Intercept	Class	MATH	HSP	ACT-SAT	PCT-SECT	Major	COMASGN	ASNDONE +ASN. LogACT	TIPS+ Interactions[a]
John Shade (Slow Student *TIPS* class)	54.63	33.6%	5.9%	...	10.0%	5.7%	14.4%	3.4%	−0.0%	7.6%	19.5%
Charles Kinbote (Average student *TIPS* class)	58.36	31.2%	5.5%	...	11.0%	16.9%	13.3%	3.1%	−0.0%	3.1%	15.8%
Sybil Swallow (Bright Student *TIPS* class)	63.69	28.8%	5.1%	...	11.4%	24.7%	12.3%	2.9%	−0.0%	1.5%	13.3%
Jack Gradus (Average Student Control Class)	49.51	37.1%	6.5%	...	13.0%	20.1%	15.9%	3.7%	−0.0%	3.7%	

[a] Interactions $= TIPS \cdot ASNDONE + TIPS \cdot ASNDONE \cdot Log(ACT) + TIPS \cdot Log(ACT)$.

feedback and study discipline. All of these influences are plausibly more beneficial to the low achiever. Moreover, given the experimental design, it is not surprising that the low-achieving student received greater benefits from *TIPS*. A larger share of instructional resources (grading and *TA*'s time) was allocated to this student, even though the *total* resources employed in each class (including the student's time) was roughly the same.

Are these measured impacts of *TIPS* specific to the "type" of examination question? The results in Table 2 suggest that

TABLE 2—CONTRIBUTION OF TIPS TO STUDENT SCORE ON THE COMPONENTS OF THE FIRST EXAMINATION

Student	Multiple Choice	Short-Answer	First Essay
John Shade (low achiever)	16.2%	29.4%	16.5%
Charles Kinbote (average achiver)	13.3%	27.0%	9.7%
Sybil Swallow (high achiever)	10.8%	24.3%	6.6%

the greatest impact of *TIPS* was revealed on short-answer, applied problem-type questions; moreover, the low-achieving student gained as much on the essay question as he did on the multiple-choice questions. Finally, the distributional impact of *TIPS* appears consistently across all types of questions, although it is most pronounced on the essay.

Other Effects of TIPS

1. *Student Evaluation of TIPS*

Students responded favorably to the employment of *TIPS*. They possessed no significant hostility to the use of data processing equipment. Moreover, they urged that *TIPS* be used in future economics classes and in other disciplines as well. The student's evaluation of *TIPS* is largely invariant to his class, major, or *ACTSAT* standing (Kelley, 1968).

2. *Student Evaluation of the Course and the Professor*

The student's evaluation of the course and the professor was uninfluenced by *TIPS*. The end-of-course evaluations (prepared by the Department of Economics and by the Wisconsin Student Union) yielded virtually identical results in the control and the experimental groups. This evidence is consistent with the hypothesis that the Hawthorne effect was unimportant.

3. *The Lasting Effects*

Approximately 250 students were retested one year after the completion of the experiment. While the results are not yet completely analyzed, preliminary findings reveal that the differential *TIPS* effect is maintained over time, although it diminishes somewhat in magnitude. This impact of *TIPS* on the retention of knowledge is probably attributed to the change in study habits engendered by the teaching approach. Students in the *TIPS* class have been shown to study and review continuously throughout the semester, allocating a relatively smaller share of their time to preparing for major examinations (Kelley, 1968, pp. 451–52). This contrasts with the "typical" study pattern of allocating a greater proportion of time to examination preparation, i.e., cramming. The latter study pattern has been shown by psychologists to represent a relatively unproductive format if knowledge retention is the criterion of evaluation.

The most interesting finding on the retention of knowledge is that the distributional effect of *TIPS* largely disappears. If this result stands up to further analysis, then clearly the "efficiency" assessments made above regarding the relative productivity of allocating a disproportionate share of instructional resources to the lower-achieving student could well be modified, and even overturned.

4. *The Number of Majors*

The proportion of the *TIPS* class selecting economics as a major, as measured two years later, was 23 percent higher than that in the control class. This unexpected result is somewhat difficult to interpret. Recall that students appeared to obtain no differential "enjoyment" of the course or instructor due to *TIPS*. Possibly their greater academic success in the course, by comparison with their evaluation of it, is the more important factor in their selection of a major.[1]

Cost of TIPS

Costs can be divided into six categories: 1) physical facilities, 2) data processing, 3) faculty time, 4) student time, 5) *TA* time, and 6) other (secretarial, administrative, printing, and so forth). A detailed examination of the differential *total* costs reveals that there is no significant difference between the per student cost in the *TIPS* and the control lectures. This somewhat surprising result is obtained from the fact that the increased direct costs of the system (computer time, professor's time in survey preparation, printing) is largely offset by the more efficient use of existing classroom resources (*TA* grading time). If an evaluation of the student's time "saved" or released by *TIPS* is taken into account, then *TIPS*, as implemented during the experiment, would have economized on total instructional resources.

Research to date has not yet determined the effects of *TIPS* on the *distribution* of costs. The major distributional impact occurs in the allocation of *TA* and student time. To the extent that *TIPS* is not used for enrichment purposes, then students of lower achievement are, on the one hand, incurring greater time costs and, on the other hand, receiving a disproportionate share of the benefits and instructional resources.

TIPS and Economic Efficiency

It is possible to form a preliminary appraisal of the efficiency of *TIPS* as used in this particular experiment. *TIPS* produces increased output for most students although, as implemented, more output was distributed to the relatively low-achieving student. Assuming a positive value of marginal output, then the sign of the total value of output is positive and is uninfluenced by the distributional effects of this instructional technique. However, *TIPS*'s distributional impact influences the *size* of the value of total benefits.

While the total cost of *TIPS* is approximately the same as in the traditional classroom format, a higher cost was assumed by the low-achieving student. Assuming that the opportunity cost of the time of this student is less than or equal to that of his brighter counterpart, I can conclude that *TIPS* is a more efficient technique than the traditional classroom framework.

Several qualifications are in order. First, these conclusions are based largely on the course examination measures. Other measures, including output-added, measures of intellectual curiosity, or critical thinking, may yield quite different findings. Second, the value of the output depends on *who* is doing the valuing. While faculty may be inclined to value strongly the impact of *TIPS* on retained student achievement of economics, students, in contrast, plausibly place a relatively high weight on course "enjoyment," somehow measured. (We have concluded that course "enjoyment" is largely invariant to *TIPS* use.) Alternatively, even the most enlightened departmental chairman, while responsive to achievement and course evaluations, will

[1] The same percentage distribution of A's, B's, and C's was awarded to each class. A difference in letter grades in this range did not therefore account for the larger number of majors from the *TIPS* class. This grading procedure was considered necessary to ensure student cooperation during the experiment.

place some positive (relatively high?) weight on the "economics-majors" output. Finally, my results apply to one experiment, with one instructor, in a single university, and in a particular course. Even if we assume that the experiment is methodologically sound, and that analytically sensible theoretical and statistical models were employed, the ability to generalize from this single experiment is limited. We would be interested in replicating this experiment in other courses, disciplines, and environments. Moreover, these experiments should ideally be outside the direct influence of the researcher.

A final qualification relates to the predicted outcome of replicating *TIPS* in other settings. A wide variation of *TIPS* impacts is likely to be identified. The impact of *TIPS* is in large part a reflection of the relative success with which the professor correctly selects the appropriate teaching instruments and test items. Given the paucity of scientifically based findings on the relative productivity of alternative teaching approaches and materials, the full potential of a *TIPS*-like approach to instruction will not be revealed until major advances are made in the more fundamental instructional areas of testing, diagnosis, and prescription. If the past can be taken as a rough guide to the future, notable advances in these areas of instruction, in economics or any other discipline, are not likely to be just around the corner.

REFERENCES

W. L. Hansen, A. C. Kelley, and B. A. Weisbrod, "Economic Efficiency and the Distribution of Benefits from College Instruction," *Amer. Econ. Rev.,* May 1970, *60,* 364–69.

A. C. Kelley, "An Experiment with *TIPS:* A Computer-Aided Instructional System for Undergraduate Education," *Amer. Econ. Rev.,* May 1968, *58,* 446–57.

———, "The Economics of Teaching: The Role of *TIPS,*" in K. G. Lumsden, ed., *Recent Research in Economics Education,* Englewood Cliffs 1970, 44–66.

W. J. McKeachie, "Research on Teaching at the College and University Level," in N. L. Gage, ed., *Handbook of Research on Teaching,* Chicago 1963.