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ABSTRACT

This review used meta-analytic techniques to integrate findings from 30 independent studies that compared programmed instruction to conventional methods of instruction at the secondary level. The meta-analysis demonstrated that programmed instruction resulted in higher achievement when compared to conventional methods of instruction (average ES=.40). No significant correlation was found between class size and effect size (r=.097, p>=.05). The most important aspect of this meta-analysis is that with this virtually zero correlation, it indicates that programmed instruction maintains its effectiveness over conventional methods of instruction regardless of class size. An appendix contains a data-coding form. (Contains 42 references, 1 table, and 5 figures.) (Author/RT)

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# Programmed Instruction in Secondary Education: A Meta-Analysis of the Impact of Class Size on Its Effectiveness

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## Abstract

This review used meta-analytic techniques to integrate findings from 30 independent studies that compared programmed instruction to conventional methods of instruction at the secondary level. The meta-analysis demonstrated that programmed instruction resulted in higher achievement when compared to conventional methods of instruction (average ES=.40). No significant correlation was found between class size and effect size ($r$=-.097, $p$>.05). The most important aspect of this meta-analysis is that with this virtually zero correlation, it indicates that programmed instruction maintains its effectiveness over conventional methods of instruction regardless of class size.

# Programmed Instruction in Secondary Education: A Meta-Analysis of the Impact of Class Size on Its Effectiveness

In 1953 following an observation of a fourth grade mathematics class, B.F. Skinner built the first teaching machine, in an effort to address what he perceived as being the violation of two fundamental principles in the classroom (Smith & Woodward, 1996). These two violations included students failing to receive immediate feedback on their work (lack of reinforcement) and expectations of all students to work at the same pace regardless of ability and preparation. These machines made a significant impact on teaching and were implemented in many classroom settings in the late 1950's and throughout the 1960's. Programmed instruction prepared schools for teaching technologies that would follow.

A large amount of research was conducted on programmed instruction by comparing examination scores of groups taught by programmed and conventional methods. These studies were completed on groups of students in all levels of education, where a variety of research designs were used and a variety of results were obtained. Many variables were analyzed to determine the impact they had on the effectiveness of programmed instruction. Inconsistencies in the research findings have prevented any clear cut pictures to be drawn regarding programmed instruction, however some patterns seem to exist. Elaboration will follow.

The research indicates that programmed instruction is more effective for social science classes than for mathematics or science. Zoll (1969) reported that only three out

of thirteen studies reviewed, found programmed instruction to be significantly superior to conventional methods of instruction for mathematics. An extensive review by Kulik, Schwalb, and Kulik (1982) summarized results from 47 comparisons of programmed and conventional instruction and found the average Effect Size in the social sciences (.57), in mathematics (-.01), and in science (.11). Briggs and Angell (1966) found favorable results in only two out of 14 studies reviewed in the field of mathematics.

Hartley (1978), and Kulik, Cohen, and Ebeling (1980) found that more recent studies of programmed instruction have shown stronger effects, as the correlation between the year and size of effect was .31. In a more recent review of research Kulik, Schwalb, and Kulik (1982) found the following Effect Sizes for the five year periods reviewed. -.01 for studies published in the years 1961-65; .14 for the 19 studies published in the years 1966-70; and .28 for the seven studies published in the years 1971-75.

Student ability is another variable that has been shown to influence achievement from programmed instruction. General intelligence appears to be related more to the pace with which a student goes through a program than to achievement according to Glaser, Reynolds, and Fullick (1967). Cassel and Ullom (1962) found programmed instruction to result in a highly significant amount of learning in mathematics for a group of high ability high school students. A large portion of the research reviewed by Zoll (1969) found programmed instruction to be as effective as conventional methods of instruction for students of average to high ability, and found conventional methods to be superior to programmed instruction for low ability students.

Briggs and Angell (1966) concluded that the more closely programmed instruction resembles conventional methods of instruction the higher will be its correlation with intelligence.

Reviews of research seem to indicate that programmed instruction is more effective in the upper grade levels. Hartley (1978) reviewed 40 research articles on programmed instruction at the elementary and secondary level and found that programmed instruction raised student achievement by .11 standard deviation units. Kulik, Cohen, and Ebeling (1980) integrated results from 57 studies at the college level to find that programmed instruction raised achievement by .25 standard deviation units. When comparing Effect Sizes within the secondary level Kulik, Schwalb, and Kulik (1982) found a range of .01 for 7th grade (five studies reviewed) and .33 for 12th grade (3 studies reviewed).

Besides the effect of programmed instruction on student achievement, student attitudes toward programmed instruction have been studied as well. Hartley (1974) in a review of literature found that 70-90% of the students involved in short-term experiences with programmed instruction responded favorably. Mellish and Bostow (1975) reported that students responded favorably and that programmed instruction seemed to improve the student's attitude toward studying. Okunrotifa (1975) found that programmed instruction produced more favorable attitudes towards map reading in geography than conventional texts covering the same span of information as the programs. These results imply that teachers may select programmed instruction as a teaching method to promote favorable attitudes toward school curriculum.

The time required to present material has been found to be shorter by programmed instruction than conventional instruction, (Hughes & McNamara, 1961). Fusfeld and

Jump (1966) reported that students who studied using programmed instruction spent much less time than students using the conventional method, yet there was no significant difference in their test scores. Other studies have also indicated reduced time for the learner (Jensen, 1949; Porter, 1959).

Extensive research has been completed, that examined the factor of class size and achievement, and this research (Glass & Smith, 1979) determined that achievement decreased as class size increased when conventional methods of instruction were used (see Figure 1). However, none of the above studies have investigated the class size factor and its effect on the Effect Size of Programmed Instruction. The present study attempts to remedy that situation. This article applies Glass's meta-analytic methodology to evaluations of programmed instruction at the secondary level. It thus serves as a supplement to previous work with other factors that influence the effectiveness of programmed instruction. This article focuses on three research questions. First, what is the average Effect Size for programmed instruction vs. conventional methods of instruction at the secondary school level? Second, what is the average class size for studies reviewed? Third, what is the correlation between class size and Effect Size for Programmed Instruction? A positive correlation would indicate a situation such as shown in Figure 2a. A zero correlation would indicate a situation such as shown in Figure 2b. A negative correlation would indicate a situation such as shown in Figure 2c.

## Method

This section describes the procedures that were used in locating studies, coding study features, and quantifying outcomes of studies.

Locating Studies

The first step of this meta-analysis was to collect a large number of studies for secondary students that compare the effectiveness of programmed instruction to conventional methods of instruction. The main sources for these studies were three library databases. These data bases included (a) Comprehensive Dissertation Abstracts; (b) ERIC, a data base on educational materials from the Educational Resources Information Center, consisting of two files Research in Education and Current Index to Journals in Education; (c) Psychological abstracts. The bibliographies in articles located through computer searches provided a second source of studies for meta-analysis.

A set of guidelines was used when reducing a pool of approximately 200 titles to a final group of approximately 30. To be included in the final sample they needed to meet four criteria. First, the studies took place in actual secondary classrooms. Second, studies need to report on quantitatively measured outcomes in both programmed instruction and conventional classes. Studies without control groups were excluded. Third, studies have to be free from crippling methodological flaws. Studies were not included if treatment and control groups clearly differ in aptitude. Nor were they included where criterion tests are taught unfairly to one of the comparison groups. Fourth, studies have to report the number of students in each class being compared.

Guidelines were used to maximize independence among comparisons and prevent studies from being counted more than once. When several papers report the same comparison, the most complete report was used for analysis.

Instrument (Data Coding Form)

The Data Coding Form (see Appendix) included (A) Reference, (B) Subject Matter, (C) Grade Level, (D) Length of Study, (E) Class Size, (F) Effect Size. The outcomes described in the studies are for student performance on final examinations and performance on retention examinations. Effect Size for each of the outcomes were calculated by using procedures described by McGaw and Glass (1980). The Effect Sizes were based on group averages for the two instructional outcomes. For the index of the size of difference between group averages, Glass's Effect Size was used. It is defined as the difference between the treatment and control means, divided by the standard deviation of the control group (Glass, 1976). In all of the 30 studies, the ES was calculated directly from means and standard deviations provided in the reports.

## Results

A total of 30 studies contained information regarding class size and achievement.

### Class Size

As shown in Table 1 the average class size for the 30 studies used in this meta-analysis was 33. The standard deviation for class size was 23.

### Achievement

Table 1 shows that the average value of Effect Size in the 30 studies was .40. The standard deviation of Effect Size was .80. Therefore programmed instruction raised student achievement when compared to conventional methods of instruction at the secondary level.

Class Size and Effect Size

The Pearson Product Moment Correlation between Effect Size and class size found there to be no significant correlation. The correlation coefficient was -.097, $p>.05$. This indicates that effect size was not significantly affected by class size (see Figure 2 & 2b).

## Discussion

Extensive prior research (Glass & Smith, 1979) found that there is a fixed line that represents a decrease in achievement as class size increases when conventional methods of instruction are used. This meta-analysis demonstrated two additional points. The first is that programmed instruction increased achievement among students when compared to conventional methods of instruction (ES=.40). Second the nonsignificant correlation (-.097, $p>.05$) between class size and effect size indicates that programmed instruction maintains its effectiveness over conventional methods of instruction regardless of class size (see Figure 2 & 2b). These findings would suggest that programmed instruction would be the instructional method of choice when teaching classes of various sizes at the secondary level.

The effect size of .40 found in this meta-analysis is somewhat surprising, given the results of a previous meta-analysis (Kulik, Schwalb, & Kulik, 1982) regarding programmed instruction at the secondary level, which found an average effect size of .08 when 48 studies were reviewed. However, previous research (Kulik, Schwalb, & Kulik, 1982) did find that the more recent (1971-1975) use of programmed instruction was more effective than earlier (1961-1965) uses of programmed instruction, which could explain the difference in the average effect size of these

two meta-analysis as 19 of the 30 studies used in this meta-analysis involved studies completed more recently than 1965. Another factor that may have contributed to these findings is that 17 of the 30 studies used in this meta-analysis involved 11th and 12th grade students and the other meta-analysis (Kulik, Schwalb, & Kulik, 1982) found an average effect size of .35 with 11th and 12th grade students when compared to an average effect size of .02 with 7th through 10th grade students. This meta-analysis established that programmed instruction was more effective than conventional methods of instruction and this may be attributed to many of these studies involving more recent research and students in the 11th and 12th grade.

The second point demonstrated by this meta-analysis involved there being no significant correlation between class size and effect size. The fact that programmed instruction was able to maintain its effectiveness over conventional methods of instruction regardless of class size, may be attributed to the sequential, work at your own pace, and reinforcement aspects of programmed instruction. As these aspects of programmed instruction seem to require more independence on the part of the student and therefore are less dependent on the teacher which makes the teacher to student ratios less important. This may explain how programmed instruction is able to maintain its effectiveness over conventional methods of instruction across various class sizes.

When interpreting the results of this meta-analysis two points should be kept in mind. First studies were located in the library by using the search term "programmed instruction." This is consistent with how previous researchers located studies, however, there may be a difference in the way programmed instruction is defined and utilized to present material to students.

Therefore programmed instruction was what teachers in previous studies said it was. Second it is important to keep in mind that a meta-analysis is a method of using previous studies to determine themes in past research, rather than making predictions for the future.

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# Appendix

## Data Coding Form

A) Reference _____

_____

_____

_____

_____

B) Subject Matter _____

C) Grade Level _____

D) Length of Study _____

E) Class Size _____

F) Effect Size _____

Table 1

Class Size and Effect Size for Secondary Students When Programmed Instruction Was Used.

| | M | SD | N |
|---|---|---|---|
| Class Size | 33 | 23 | 30 |
| Effect Size | .40 | .80 | 30 |

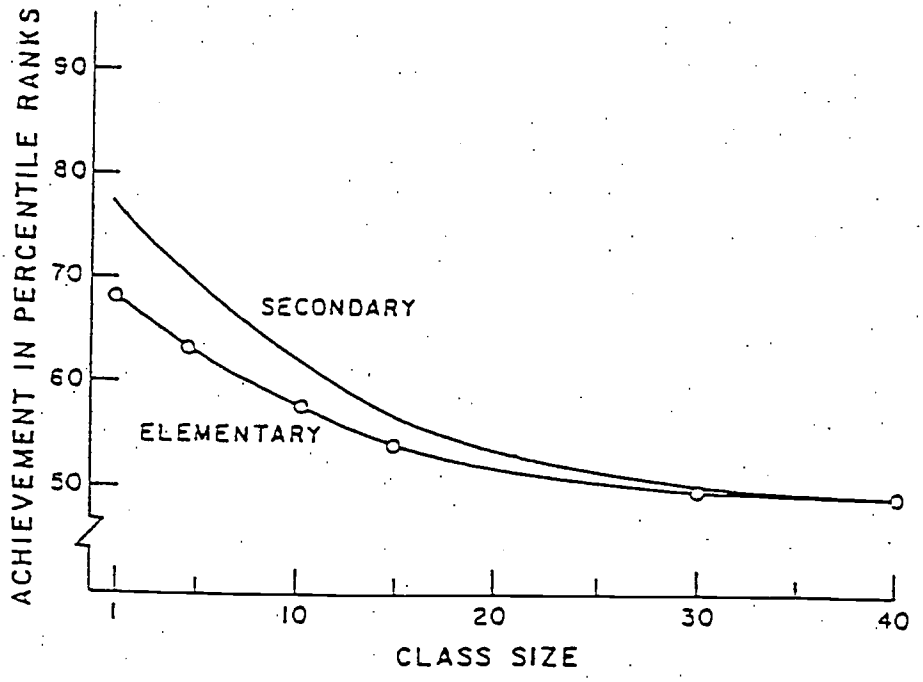


Figure 1. Consistent regression lines for the regression of achievement (expressed in percentile ranks) onto class size for elementary and secondary grades (Glass & Smith, 1979).

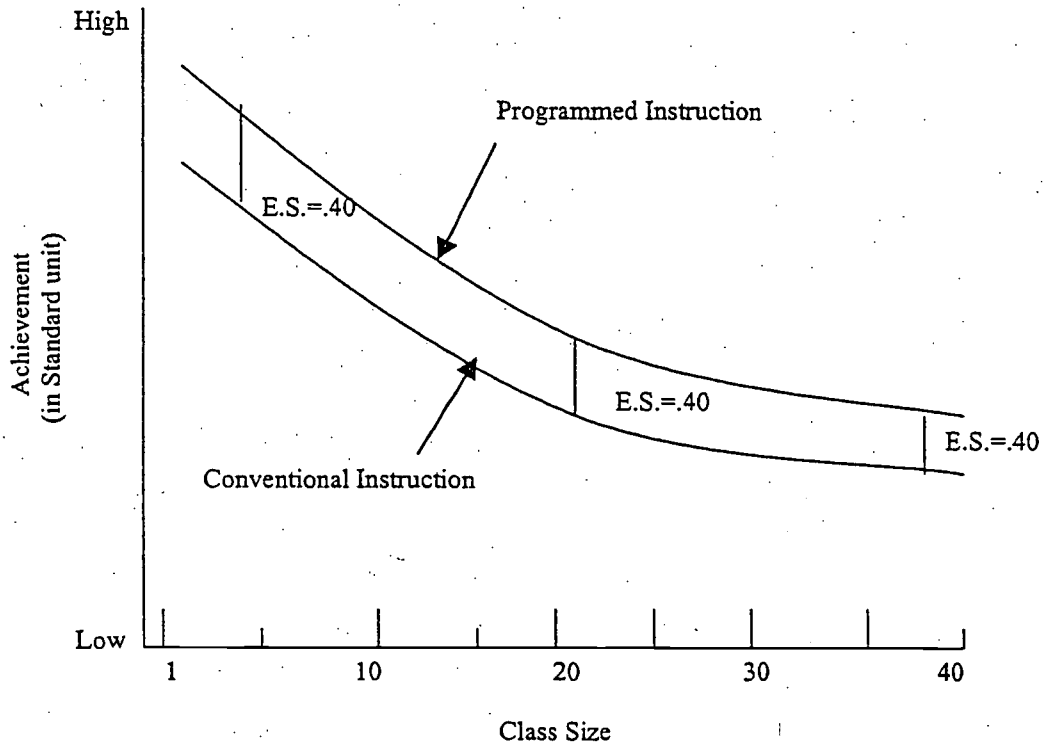


Figure 2. Consistent regression lines for the regression of achievement onto class size for studies involving secondary students, where either Programmed Instruction or Conventional Instruction was used.

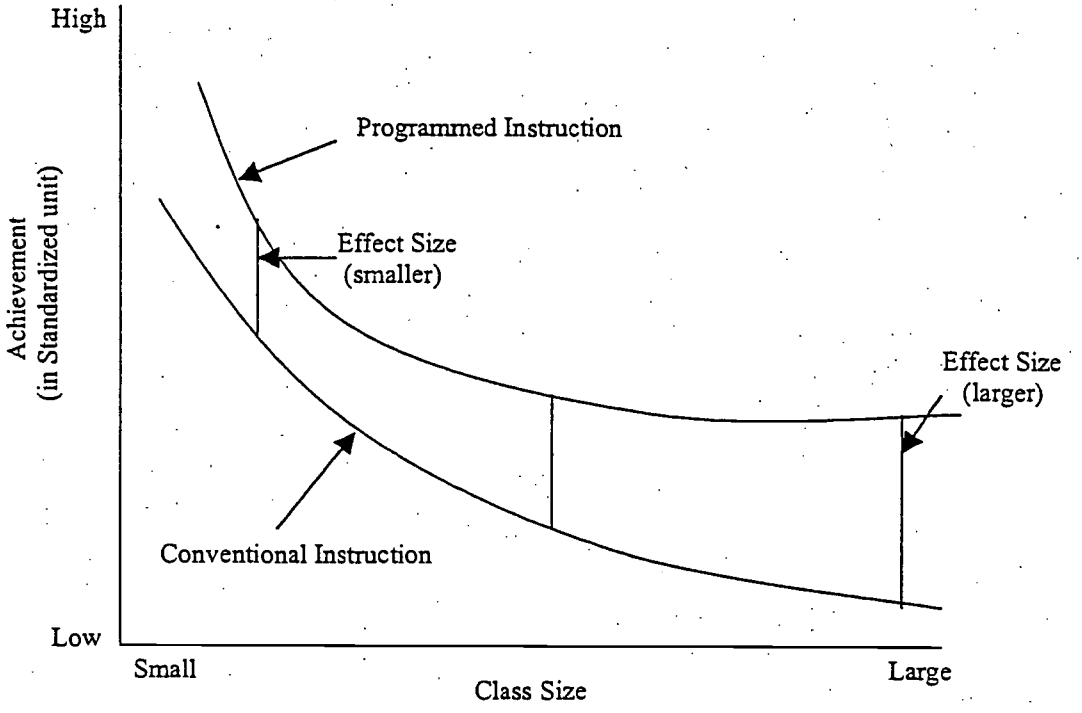


Figure 2a. Positive correlation between class size and Effect Size.

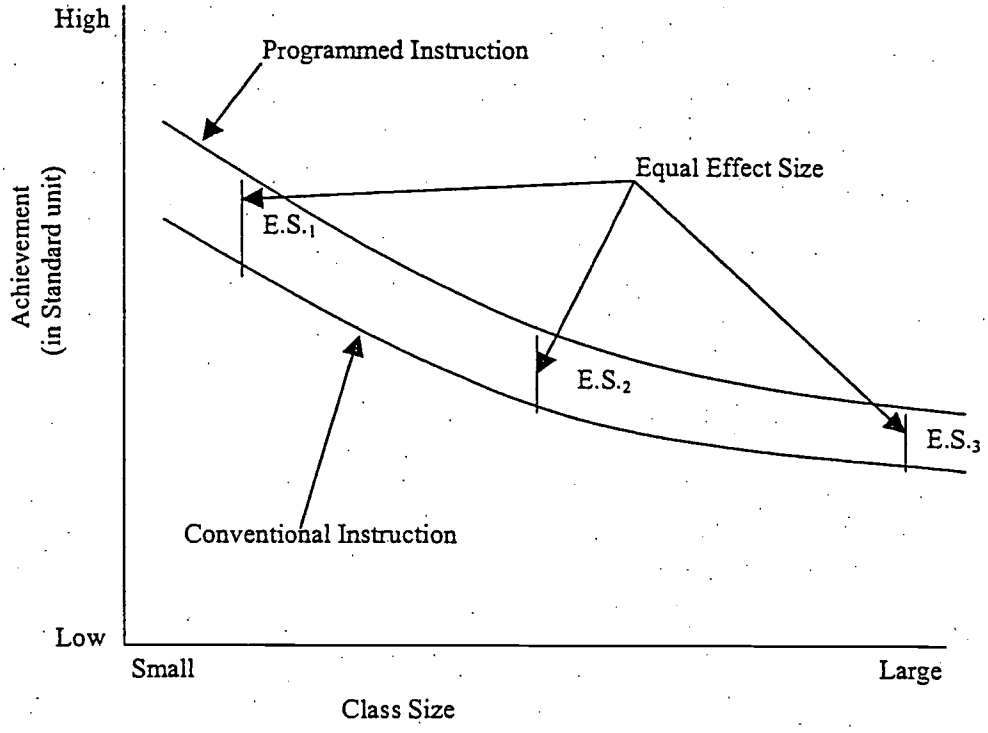


Figure 2b. Zero correlation between class size and Effect Size.

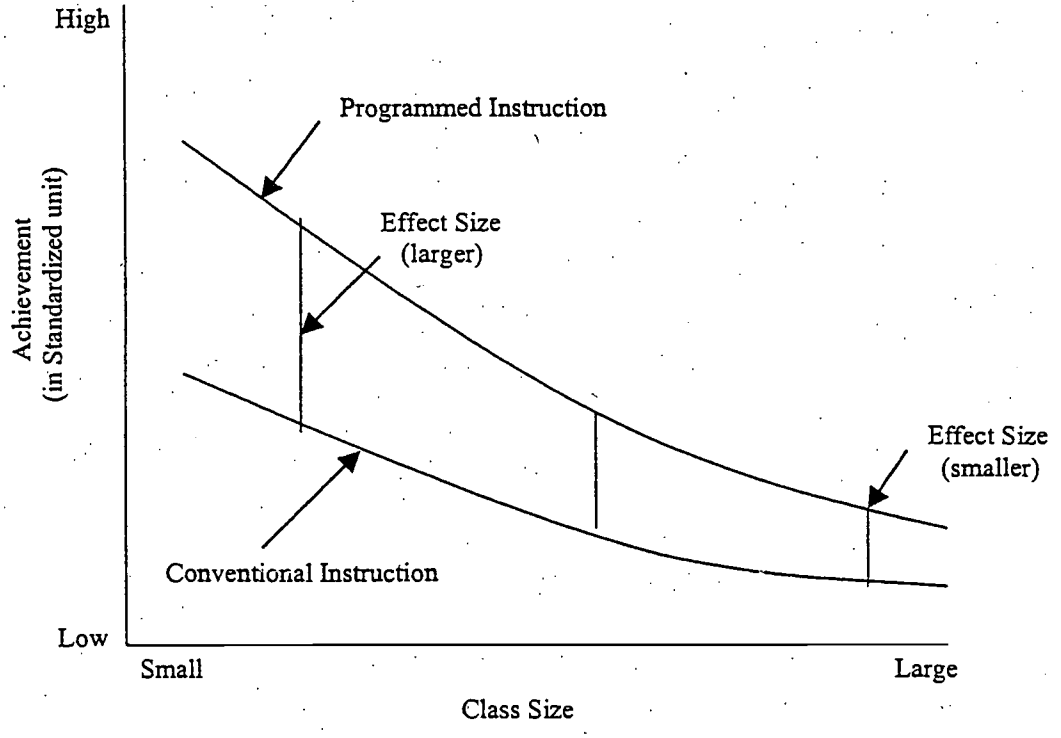


Figure 2c. Negative correlation between class size and Effect Size.

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