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ABSTRACT

This paper examines comparative educational program evaluation. Suggested evaluative criteria and evaluation techniques and their weaknesses are discussed. An evaluation formula is proposed, and an example of its operation is provided. (DG)

PROCEDURES FOR COMPARING INSTRUCTIONAL PROGRAMS[1]

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The utility of various techniques for comparing the effectiveness of different instructional programs is becoming an important topic in the field of educational evaluation. As Popham (1969) points out, one reason for this increased interest in program comparison techniques is that instructional programs, promising specified changes in learners, are becoming essentially replicable. This means that we now have the opportunity to select from among competing instructional programs. Pressure for developing valid and informative program comparison techniques also is emanating from major educational funding sources. These funding sources want to know which programs (or program components) are effective and which are not so that they can allocate their support accordingly.

The very range of programs currently on the market, however, has already made it difficult for decision makers to select among them. This selection process is further complicated by the fact that alternative programs, even those designed for the same general content area, frequently focus on different objectives and vary in their success in achieving these objectives. Competing programs, also, often require different amounts and/or kinds of resources, personnel, and time.

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[1]Paper presented to the American Educational Research Association Convention, Chicago, April 4, 1972.

Factors to Consider

This situation has recently led a number of researchers to suggest various methods for making program comparisons. It is necessary, however, to examine the major program factors any effective program comparison technique should take into consideration, before one can make an informed decision about their relative merits. Six of these major factors are as follows:

(1) Success on the Objectives

(2) Relative Importance of the Objectives

(3) Number of Objectives and their Overlap

(4) Time Spent in Achieving the Objectives

(5) Number and Kinds of Students Involved

(6) Costs and Resources

Success on the Objectives. It is generally agreed that the foundation of any good educational evaluation system is a clear statement of relevant program objectives. Further, these objectives should be stated in a way that makes them measurable. Once this is done, it is possible to assess student performance with respect to the degree to which the objectives have been obtained. It is obvious, therefore, that when the other variables noted above are held constant, one program is considered better than another when it has more success on its objectives.

Relative Importance of the Objectives. A second way we can judge whether one program is better than another is in terms of the importance of the objectives it achieves. Thus, a program that has a moderate degree of success on very important objectives

may be more valuable than one that has a high degree of success on objectives which are relatively less important. For example, a program that results in 50% of the students being able to read at grade level would probably be more valuable than one that results in 90% of them being able to name all the states in the Union and their capitals.

Any system for comparing the effectiveness of programs or program components, therefore, must consider the relative importance of the objectives being attempted. But it also must be remembered that although the difficulty of achieving a given objective is likely to be positively related to the objective's importance, the two are not synonymous. Further, difficulty in and of itself has no social significance. For example, of the two objectives listed below, the first is probably much more difficult than the second to achieve. The second one, however, is likely to be considered more important to achieve:

(1) 90% of all high school graduates can find the square root of any 5 digit numeral.

(2) 90% of all high school graduates can balance a checking account.

Number of Objectives and their Overlap. Another area of major concern in the comparison of programs is the number of objectives and their overlap. Where all other things are constant, we can consider a program that achieves more objectives than another program to be more desirable. As was mentioned earlier, however, programs often differ in the number of objectives they attempt to

achieve, and a problem will arise if we attempt to compare a program having moderate success on many objectives with a program having a great deal of success on just a few objectives.

This problem is by no means solved, however, if program comparison is limited exclusively to objectives that are common to both programs. For example, one program may have substantial success on the overlapping objectives but it focuses exclusively on these while a second program may have moderate success on many objectives including those that overlap with the first program. In other words, a program may look better than it actually is simply because it attempts to accomplish less than another. Any system for comparing programs, therefore, must adjust for the number of objectives attempted in each program.

Time Spent in Achieving Objectives. All other things constant, the less time a student spends in achieving an objective, the more effective the program. There are, of course, several reasons for this, such as the fact that time means money, after awhile pupils become bored with any subject, and it becomes harder to teach, and time used for one purpose cannot be used in achieving other objectives.

Number of Students. A fifth way we can assess whether one program is more effective than another is in terms of whether it improves the performance of more pupils. Unlike the examples in simple statistical texts, however, the practitioner often encounters situations in which he must compare one program that achieves success with a few students versus one that achieves somewhat less success but has many students. It is apparent, therefore, that

any good program comparison method should control for the number of students involved since this will directly influence the program's impact. This is especially true when comparing new programs since a program frequently is more successful when tried out in a few classes than when it is used throughout a district.

Program Costs. All other things constant, one program is more effective than another if it costs less to operate and still achieves the same degree of success. In comparing programs, however, one must take into consideration the fact that although one program may result in higher levels of student performance than another and in less time, it is only able to achieve this at a much higher per pupil cost.

The cost issue also reflects on the fact that school and government administrators want more information than just student performance in order to make decisions about programs. In other words, they want to know about the relative importance of objectives, the number of objectives, the number of pupils involved, and the time and costs needed to achieve the objectives. All too often they must rely on subjective and faulty appraisals of these latter factors since the program evaluators have only reported on average student performance. Thus, in order to provide a more valid basis for making program decisions, evaluators should provide administrators with a consistent and systematic approach for considering all the major program factors that influence such decisions.

Earlier Techniques for Comparing Programs

If we use the six factors noted previously as a set of

standards for any program comparison technique, then we must conclude that a great many of the current techniques are too simplistic to provide any worthwhile comparative information. In determining which of two or more competing instructional programs is best, for example, the decision is often made on such extraneous considerations as packaging of materials, their format, and their illustrations. While we may keep such considerations in mind, it should be obvious that they provide no real information in terms of program effectiveness in meeting objectives. Similarly, decisions concerning which program to select are often based on purely subjective considerations such as style or philosophy in the program's treatment of content. Again, such considerations are almost worthless in terms of providing information which can be used to decide upon program success in meeting objectives.

Independent Tests. One technique for comparing programs that is employed quite often involves the use of a nationally normed standardized test across all the different programs being compared. There are several advantages in applying this method. First, this type of measure is constructed without intentional bias for one program over another and, hopefully, will not favor the content of one program over another. Further, the same measure is given in all programs under the same conditions and there is a set of norms and other related information available with the instrument to help in interpreting results. Third, the test construction procedures used in these instruments are generally good compared to

locally constructed instruments. Finally, they are relatively inexpensive and readily understood by laymen.

There are, however, many disadvantages in using the independent test technique. For example, such tests ideally will not be biased in favor of one of the programs being compared; they may inadvertently favor one program over another in terms of emphasis on the objectives measured (Klein, 1970). Further, such tests may not cover all the relevant objectives in each program or even all those that overlap programs. More importantly, the methods of test construction and score reporting of most nationally normed instruments do not emphasize providing information about student performance on specific objectives (Klein, 1971), they do not consider differences in the number of objectives covered, and they neglect some of the other important considerations that were discussed in the introduction to this paper.

Program Unique Tests. A different method of program comparison is discussed by Wolf (1968). In this technique, each program has its own unique test for its specific objectives. Program comparisons are made solely on the basis of the degree to which students in each program achieve the objectives for their program. The advantages of this approach over the use of the standardized tests technique are that tests are designed specifically for each program and students do not have to take test items dealing with material that they have not covered.

Despite these advantages, this method still has several shortcomings. For example, it offers no techniques for handling differences in test difficulty, number of objectives covered, importance of the objectives, or the time spent on them.

To meet the shortcomings in the methods discussed above, other techniques have been developed which, in a very restricted sense, provide for better comparison of programs. Two of these methods which we will discuss, while providing some advantages over earlier methods, are still extremely limited in that they require that the programs being compared either have common objectives or objectives which overlap to a high degree.

Program Free Testing. One of the more recent methods for making comparisons is called Program Free Testing (Wolf, 1968). This method involves using a test which has been constructed to assess those objectives or program elements common to all the programs being compared. The first step in this method is to compile a list of those objectives which are common across programs and then to construct test items for these objectives. After the test has been administered, the average scores of students in the various programs are compared.

The advantages of this method are that a common measure is used across programs and it focuses on specific but common program objectives. By focusing on common objectives, however, this method fails to consider those objectives which are unique to each program; and these latter objectives may be more important than the common objectives. Further, the method is highly dependent upon a large degree of overlap between program objectives, and thus, if this overlap is slight, then only a small aspect of each program is considered. Finally, like the other methods discussed, Program Free Testing still fails to consider such factors as

differences in the relative importance of objectives across programs and the number of objectives each program is trying to achieve.

Program Fair Testing. A second recent method of making program comparisons involving overlapping objectives has been developed by Popham (1969). This method, Program Fair Testing, has one advantage over the others in that it at least recognizes that programs being compared may not always have totally common objectives. Popham suggests that the objectives of each program be identified and then grouped according to whether they are common to the programs being compared, unique to one program, or unique to another program. Tests are then constructed for each set of objectives so that three or more subtests are developed; that is, one subtest for the objectives common across programs, and one for the unique objectives of each program being compared. Students in each program receive two tests, i.e., the test for the common objectives and the test for the objectives unique to their program. Based upon performance of the various groups of learners, and considering the relative values of each set of objectives, a comparison can be made to determine which of the programs should be selected.

This technique offers several advantages in that it uses a common measure across programs, it pays attention to unique objectives within each program, and recognizes differences in the relative importance of objectives. The method is again limited, however, in that it still relies heavily on overlapping objectives.

In addition, the procedure makes no provision for systematically handling differences in the relative importance of objectives, the number of objectives covered, and related factors, although Popham does state that they are important considerations.

Unanswered Questions

Of the techniques for program comparison that we have discussed so far, the Program Fair and Program Free Testing provide better information than previous methods. Both are limited in scope and application, however, as evidenced by the fact that they are appropriate only when program objectives are common or at least overlap to a fairly high degree. In addition, they both leave unanswered many questions which must be addressed if we are going to perform realistic comparisons of different programs. For example, what are we to do if the objectives of the programs being compared do not overlap to a very high degree? Or if they share no common objectives? What if we are faced with a more complex situation such as when one program has a total of 25 pupils, takes all year, and has ten objectives; while a second program has 500 pupils for a semester and only has five objectives, and only two of these overlap the objectives of the first program?

As we have seen, comparisons based on independent tests or just success in meeting program objectives do not answer the questions raised above, nor do these methods adequately consider the many other factors we have identified as being essential to valid program comparisons. As an attempt to move one step forward in resolving this problem, the remainder of this paper is devoted

to a description of how the six basic factors we have identified might be incorporated into a potentially more effective program comparison technique.

General Formula for Determining Program Effectiveness

Any method of comparing programs should take into consideration all the major factors that might influence the relative effectiveness of one program over another. The formula below depicts the general relationships of these program characteristics:

$$\frac{(S)\ (N)}{(T)\ (C)} = E$$

Where: S = the sum of the total weighted scores for all the program's objectives (where the scores on each objective are some function of success on the objective relative to its judged importance).

N = number of pupils in the program.

T = amount of pupil time spent in the program.

C = cost of running the program.

E = general program effectiveness.

The rationale for this formula is that general program effectiveness will increase if one or more of the following variables increases: number of objectives, success on the objectives, relative importance of the objectives, number of students in the program; or if the pupil time and/or program costs decrease. The key to this formula is that the relative importance of objectives across programs is based on a common scale and thereby eliminating the necessity of overlapping objectives. How this formula can be

used for comparing programs will be discussed after the consideration of the general problems inherent in calculating the appropriate numbers of S, N. T, and C.

Problems and Guidelines Associated with the General Formula

Like most general formulas, the one suggested above has its problems. Some of these problems are applicable to the field of evaluation in general while others are especially central to the issues associated with comparing programs. Some of the important problems associated with each of the six major program characteristics are discussed below along with some suggestions for how to deal with these problems in using the general formula.

Success on the Objectives. Some of the major problems associated with comparing programs in terms of their relative success on the objectives are as follows:

1. Type of score reported. The number of test items and the method of measurement often varies across objectives both within and between programs. It is necessary, therefore, to convert performance on different objectives to a common scale, such as the average percent correct, average number of students per class achieving mastery, or the average time it takes a student to achieve mastery. There are, of course, other scales that might be used and the choice of which one to use might have a profound influence on the conclusions drawn from the data (see Appendix A for an example).

2. Difficulty. Different assessment instruments, even for the same objective, often vary in their difficulty. Thus, one program may appear to be more successful than another program in reaching its objectives simply because it is using easier measures. Thus, whenever possible, the same set of items should be used to assess performance on a given objective if that objective is applicable to different programs.

3. Scaling. The difficulty of "items" within a test for a given objective usually are not equal nor do they have equal intervals of difficulty between them. For example, it may be easier to improve 10 points near the low end of the score distribution than near the high end.

4. Validity. The more valid a measurement instrument is (i.e., actually measures the objective rather than an approximation of it), the more sensitive it is to changes in student performance. Thus, differences in measurement validity across objectives may create the false impression that some objectives are achieved more than others when the real reason is that the instruments used varied in their ability to assess the precise level of student performance.

5. Reliability. Misleading differences and similarities in student performance across objectives and programs can also be caused by variations in the consistency with which instruments measure different objectives. The reliabilities of instruments used in most evaluation studies, however, are usually sufficient to minimize this problem, especially when decisions about program effectiveness are based upon group rather than individual scores.

Relative Importance of Objectives. There are several ways of determining the relative importance of objectives. One of the simplest and most efficient of these techniques is to have a panel of relevant judges rate the total set of objectives (i.e., for all the programs being compared) on a common scale (e.g., from "5" = very important down to "0" = very unimportant, or irrelevant) or by having them distribute a total set of points among all the objectives to be evaluated.

Number of Objectives. The present general formula may be biased in favor of a program that has moderate success on many easy but relatively unimportant objectives versus one that has only limited success on a few very important objectives. In

typical situations involving program comparisons, however, the most likely source of major differences in the number of objectives is the level of generality at which they are written. This problem can be partially rectified by redefining and explicating objectives so that they are all written on the same level. The method noted above of distributing a total set of points among all the objectives to be evaluated (rather than assigning absolute weights) also would help to counterbalance the effects of differences in the generality in which objectives are stated across projects. The reason for this is that the sum of the weights assigned to a set of relatively specific objectives would presumably be the same as that assigned to the more general objective from which the specific ones are derived.

Time Spent in Achieving Objectives. Collecting valid information about the pupil time spent on achieving program objectives is at best a difficult task. One reason for this is that teachers do not have the time to keep track of this information on a day to day basis for a class as a whole let alone for individual pupils or objectives. It is possible, however, for teachers to make a fairly accurate estimate of the general amount of time the class as a whole has spent in a particular program. Such time estimates should probably be limited to time spent in school and/or under direct supervision by the teacher rather than try to judge and include such things as homework time. These estimates should be in terms of the average number of hours (or days or weeks) the typical pupil spends in the program.

Number of Students. There are several ways of indicating just how many students are in a given program, such as the number of students listed as enrolled, average daily attendance, and the number of students tested or measured for evaluation purposes. The latter method, however, has several advantages, e.g., it reduces complicated record keeping and it focuses on pupil progress at the time the evaluation is being conducted. This approach also allows the general formula to correct for certain possible biases in the data, such as excluding potentially poor achievers from taking the tests so as to make the group's average higher than it really is (the general formula takes this into consideration in the sense that program effectiveness is a function of both success on the objectives and the number of students tested). Despite these corrections, it would still be a good idea to include a listing of the students tested relative to those enrolled (perhaps broken down by age, sex, or some other salient characteristic) to ensure that the students tested are truly representative of the students who are supposed to be in the program.

Program Costs. The various methods used for establishing program costs is not the focus of this paper. This and related issues have been discussed by Hartley (1968) and others, however, some factors which should be considered in establishing program costs are:

1. Long-run versus short-run costs; e.g., can the same equipment be used the following year and therefore permit its cost to be spread?

2. Cost efficiencies in having more or less students in the program; i.e., is the per pupil cost influenced by expanding or contracting the program?

For simple program comparisons, it may be more efficient to limit the cost analysis to easily computed variables such as materials, staff, etc.

Special Properties and Limitations. The general formula for computing program effectiveness has certain properties that in some ways enhance and in other ways limit its utility. One of these properties deals with the fact that some of the factors discussed above are not independent of one another. The number of students enrolled in a program and that program's cost, for example, are generally positively related to each other. Similarly, the number of program objectives relative to their weighted importance and the amount of time spent on trying to achieve them are also likely to be related to one another. Although the general formula handles this problem (e.g., doubling program costs while doubling the number of students would have no impact on the value for E), it does not make any provision for the relative importance of various factors. In other words, some decision-makers might like the formula to give more emphasis to success on the objectives in determining program effectiveness while others might like to see a greater weight given to program costs. Multiplying the values for S, N, T, and C in the formula by the desired weights would, of course, permit such differential emphasis on major program characteristics.

The general formula also contains a very mixed bag of measuring scales, e.g., hours, weighted test scores, and dollars. Thus, small variations in one factor (such as costs) might have to be offset by rather major changes in another factor (such as weighted success) in order to obtain the same value for "program effectiveness" (E). It should be noted, however, that the purpose of the formula is to compare programs in terms of their relative effectiveness and not to make judgements about their general effectiveness in any absolute sense. When it is used properly, therefore, these differences in scaling are matched between programs (i.e., costs of one program are considered relative to costs in another, hours spent in one program are compared to hours spent in another, etc.). The next section of this report, computational procedures, discusses in more detail this emphasis on the formula's use for determining a program's relative effectiveness.

Computational Procedures and Numerical Example

Listed below are the basic steps used in comparing the effectiveness of alternative programs. A numerical example accompanies these steps to illustrate the necessary computations in employing the general formula for the comparison of two programs.

1. Operationally define each of the four major components of the formula, i.e., total weighted score on the objectives, number of students in the program, total time spent in the program, and total program costs. These definitions must, of course, be the same for all the programs being compared. The operational definitions for the numerical example are as follows:

a. Total weighted score(s). The series of calculations needed to obtain this score are as follows:

(1) Compute each student's score on each objective in terms of the degree to which he has mastered the objective (e.g., 10%, 20%, etc.).

(2) Compute the average of these proportions on each objective for all the students in each program.

(3) Multiply the average proportion of success on each objective by its weighted importance. These weights are determined using the procedures described on page 13 of this report.

(4) Compute the sum of these weighted averages for each program.

The raw test data for this example appears in Appendix B. The summary results for each program appear in the table on the next page.

b. Number of students. For the purposes of the present example, this will be the number of pupils tested in each program, i.e., $n_1 = 20$, $n_2 = 25$, and $N = 45$.

c. Time. The typical student spent 10 weeks in program #1 and 15 weeks in program #2.

d. Cost. The total cost of running program #1 was $750.00 and the total cost of running program #2 was $1,000.00.

Table 1. COMPUTATION OF TOTAL WEIGHTED SCORES

	Program I (n = 20)				Program II (n = 25)				
	A	B	C	D	A	B	C	D	E
TOTAL % CORRECT	1420	1420	1310	1520	1530	1530	1490	1480	1320
$\bar{X}$ % CORRECT ON THE OBJECTIVE	71.0	71.0	65.5	76.0	61.2	61.2	59.6	59.2	52.8
$\bar{X}$ WEIGHTED IMPORTANCE OF THE OBJECTIVE	5.0	4.5	4.0	3.5	5.0	4.0	4.0	3.5	3.0
WEIGHTED SCORE ON THE OBJECTIVE	355	320	262	266	306	245	238	207	157

$$s_1 = 355 + 320 + 262 + 266 = 1203$$

$$s_2 = 306 + 245 + 238 + 207 + 157 = 1153$$

2. Compute e for each program as follows:

$$\frac{(s_1)\ (n_1)}{(t_1)\ (c_1)} = e_1. \qquad \frac{(s_2)\ (n_2)}{(t_2)\ (c_2)} = e_2.$$

In terms of the numerical example, the values for e_1 and e_2 are as follows:

$$\frac{(1203)\ (20)}{(15)\ (2000)} = e_1 = .80 \qquad \frac{(1153)\ (25)}{(10)\ (1000)} = e_2 = 2.88$$

3. Compute E as follows:

$e_1 + e_2 = E$ thus, $\underline{.80} + \underline{2.88} = 3.68 = E$

4. Compute the following ratios and convert to %:

$100 \times \frac{e_1}{E}$ = relative effectiveness of program #1

$100 \times \frac{e_2}{E}$ = relative effectiveness of program #2

$$100 \times \frac{.80}{3.68} = 22\% \qquad 100 \times \frac{2.88}{3.68} = 78\%$$

It is apparent from the foregoing results that program II is more effective than program I. It should be remembered, however, that this conclusion might be quite different if one wished to differentially weight the values of S, N, T, and C in the general formula.

Summary & Conclusions

The first portion of this paper discussed six important factors that should be considered in comparing the relative effectiveness of educational programs, e.g., the students' performance on the programs' objectives and the costs involved in achieving these objectives. The second portion of this paper examined the relative utility of previous techniques that have been used for making such comparisons. The major weaknesses of these techniques is that they fail to take into account several of the important factors that should be considered as well as place too much on the comparability (or at least partial overlap) of objectives across programs.

The final section of this paper presented one way in which the foregoing problems might be handled. This approach uses as its common denominator the relative importance of objectives across programs. It also considers systematically each of the six important factors that should be taken into account when one is comparing the relative effectiveness of various programs. Thus, the approach suggested in this paper is qualitatively different than previous ones since its focus is upon the kinds of factors that influence decisions regarding program selection. Whether or not the particular procedures outlined in this paper are adopted is, therefore, of relatively secondary importance. What is critical is that the suggested procedures highlight the kinds of factors that must be taken into consideration if one wishes to make valid program comparisons.

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Appendix A: Data for Numerical Example

PROGRAM I

Pupil	Objective				TOTAL
	A	B	C	D	
1	50	40	20	60	170
2	60	70	60	80	270
3	100	100	90	90	380
4	80	90	90	100	360
5	60	50	50	70	230
6	80	70	60	80	290
7	70	90	100	60	320
8	70	80	50	90	290
9	60	60	60	60	240
10	50	50	40	60	200
11	40	40	30	30	140
12	100	100	90	100	390
13	90	100	100	100	390
14	80	100	90	90	360
15	90	100	100	90	380
16	40	30	50	60	180
17	50	50	30	50	160
18	70	50	60	60	240
19	80	70	40	90	280
20	100	100	100	100	400
Total % Correct	1420	1420	1310	1520	
Weighted Importance	5.0	4.5	4.0	3.5	

Appendix A: Data for Numerical Example

PROGRAM II

Pupil	Objective A	B	C	D	E	TOT
1	20	80	60	70	40	27
2	30	30	10	20	20	11
3	50	60	20	60	10	20
4	20	40	40	50	60	21
5	80	80	60	90	70	38
6	70	70	70	80	80	37
7	70	70	100	40	60	34
8	60	40	60	30	40	23
9	30	20	20	20	20	11
10	100	80	90	90	100	46
11	80	70	70	100	70	39
12	90	100	90	90	80	45
13	100	90	100	100	90	48
14	80	90	70	90	60	39
15	50	50	70	40	50	26
16	100	60	60	50	50	33
17	20	10	40	20	50	14
18	70	80	60	90	40	34
19	30	50	40	30	20	17
20	30	20	20	40	10	12
21	80	60	60	40	40	28
22	40	30	50	20	70	21
23	100	100	100	90	90	48
24	90	100	100	90	80	46
25	50	40	30	40	20	18
Total % Correct	1530	1530	1490	1480	1320	
Weighted Importance	5.0	4.0	4.0	3.5	3.0	