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ABSTRACT

Wise allocation of resources implies knowledge of which actions will yield the highest net benefit. Predicting benefit requires comparing objectives as to importance and setting priorities among them. This article discusses ways in which policy-makers can set priorities rationally. The advantages of ratios for comparing priorities are discussed. The value contribution technique for estimating priorities is described and illustrated with a set of educational objectives. Applications of the method in Asia are reviewed, and the technique is evaluated. (Author)

SCALING PRIORITIES: THE VALUE CONTRIBUTION METHOD

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INTRODUCTION

In any society there are far more objectives worth achieving than there are resources to achieve them. It makes sense to apply the limited resources available to those objectives which are most important, giving due consideration also to cost effectiveness of action alternatives. This calls for setting priorities among objectives, priorities which reflect the public interest. The problem of setting priorities occurs at all levels of government, in business, for that matter in nearly any organization where decisions are based partly on human values. The issues and methods discussed here, though developed for educational decisions, are equally applicable to other settings.

To set priorities is to make a conscious judgment that some objectives deserve more immediate attention or more effort than others. It may be the judgment of one person or a social consensus such as a majority vote. The judgment may be a direct intuitive decision, or the result of a rational analysis. In order to set priorities rationally, policy makers must first know what their objectives are. Many policy analysts work in an environment of confusion over objectives. Their clients are not always sure what they want to do and sometimes the analyst has to insert his own objectives in order to get on with the job.

Our experience in consulting and conducting workshops on objectives, mainly in education, convinces us that the whole concept of objectives as a systematic guide to policy and action is still rather unfamiliar terrain to most policy makers. Means and ends are seldom clearly distinguished. Objectives are often stated so generally as to be of little use,--"a well rounded life," "a smoothly running organization," "the good society." Because measurement of how well an objective is achieved is often difficult, there is a tendency to undermine the purpose of stating objectives (to make clear what you want) by stating only those things which can be measured easily. To boot, the whole idea of specifying objectives is often challenged by executives and professionals with the argument that rational analysis in terms of objectives fails to account for their complex intuitive achievements.

Such difficulties notwithstanding, the art of specifying objectives seems to be gaining momentum in many policy arenas. On the other hand, methods of setting priorities among objectives are a good deal less advanced. A few tentative schemes recently proposed in the field of education are briefly described in a later section, but in practice, priorities in all fields have been set almost entirely by intuition. This article explores rational ways to set priorities among objectives, where priority is determined by the relative benefit expected from achieving different objectives.

There is no escape from the matter of priorities. Either priorities are set explicitly or they are implicit in the actions and policies adopted. Since implementation and corrective actions are generally much more costly than planning, there is much to be said for examining priorities in advance as a part of planning. If priorities are not set, resources many be allocated to whichever needs capture the attention first, or by the convenience of the moment, or, as is quite common, they may be allocated in the same way they have been for years because this does not rock the boat of established prerogatives.

In a field like education where there are typically many objectives during a policy decision, if priorities are not set explicitly there is a tendency either to ignore some objectives or to lean in the direction of giving stated objectives equal priority. As an example of the latter, the English language curriculum of a school may cite as objectives "can communicate clearly to a classmate in writing," and "can organize written matter effectively, using paragraphs and headings." Alongside these important general objectives may appear 20 to 30 objectives dealing with specifics of punctuation, grammar and spelling ("uses quotation marks correctly," "capitalizes proper nouns," etc.). Objectives in the area of language mechanics tend to be spelled out in great detail because they are easily broken down into concrete elements. The danger of not setting priorities is that mechanics may be given a great deal more attention in that school than are clear communication or organization of writing, simply because mechanics objectives fill three pages and the others less than half a page. When asked explicitly, educators and school boards will usually respond that clear communication and organization are far more important than any of the mechanics objectives, and perhaps more important than all of them combined. But if details of English mechanics dominate the content of statements of objectives, there is a natural drift toward allocating resources mainly to mechanics.

Since most policymakers have not stated their specific objectives the more common problem is identifying exactly what it is that policymakers are trying to accomplish. If the policymaker is unclear about objectives but quite clear about his policy alternatives, these policy alternatives may be the main focus of the policy analyst. In this case objectives may emerge only as specific benefits and costs in an overall study of policy options.

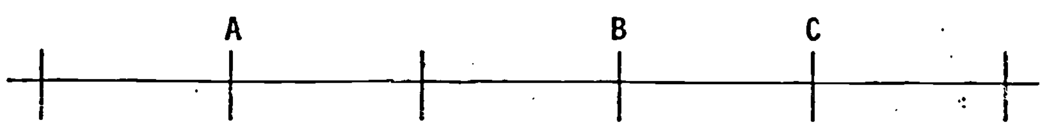
We favor specifying objectives and their priorities separately before analyzing action alternatives. Policymakers have a natural tendency to focus their attention on concrete action plans and to look at the consequences only secondarily (Campbell and Markle, 1967). A goal for which no plan of action comes readily to mind is often ignored entirely. If the priorities of goals are determined in advance, policymakers and analysts may be better motivated to search hard for new ways to achieve those top priority goals which have been given little attention in the past.

Quantitative Scales of Priority

Many policy analysts are pessimistic about quantifying total utility or benefit, especially in the area of social benefits and costs (Quade, 1975). Priority, as a measure of expected benefit, is subject to the same problems. We have found numeric scaling to be useful in setting priorities, despite the uncertainties of measurement, the questionable validity of formulas, and the dangers of uncritical deference to "number magic" by some policymakers. A skeptical attitude by both policymakers and analysts is indeed key to intelligent use. Quantification is an aid to thought, not a substitute for it. As long as users treat it this way, it can be helpful to policy analysis.

Benefit has been quantified on many different scales. Stevens (1951) defines three types of scales for measurement along a dimension: ordinal, interval, and ratio. The ordinal scale puts measured objects in rank order but tells nothing of the relative distances between ranks. For example, if three educational objectives were ranked first, second and third priority, this would give no indication of whether the first had a lot higher priority than the second and the second only slightly greater than the third, or if the differences were nearly equal.

An interval scale defines equal intervals on the scale so that differences in priority may be compared using cardinal numbers. For example, on the scale below,



the difference in priority between objectives A and B is three times as great as the difference in priority between objectives B and C. However, an interval scale does not enable one to put priorities in proportion to one another and say, for example, that one objective has twice the priority of another.

A ratio scale corresponds to the ordinary scale of real numbers and does permit meaningful ratios or proportions to be expressed. Thus, the achievement of an objective with a priority of 8 would be expected to reap twice as much benefit as achievement of an objective with a priority of 4. And a priority of 0 would indicate no benefit at all to be expected from achievement of the objective. A ratio scale, in other words, has a meaningful zero point from which distances can be measured and compared in ratios or multiples.

Another unit of benefit is the amount of time a given person would give in order to obtain or not lose the benefit. Both money and time have different subjective worth to different people, of course, so that direct estimates of benefit should be made by the same people if they are to be compared.

Since priority is the same type of dimension as utility, a benefit ratio of priority is equivalent to the economists' cost-benefit ratio of utility. Some critics of cost-benefit ratios (McKean, 1958; Hitch, 1958) prefer to use a cost-benefit difference to assess utility. For example, if the total estimated benefit of an alternative is $1,000 and its cost is $800, then its net utility is the difference, $200. Their main objection to ratios is that the unit of benefit or cost may actually differ in subjective worth at different extremes of the scale. For example, a dollar may be of greater worth in a $5 transaction than in a million dollar transaction. In such a case ratios would not be equivalent throughout the scale.

However, the same criticism applies to differences; if the scale is distorted the comparison will be biased. Whether the bias is greater with ratios or differences depends entirely on the specific numbers and distortions assumed. In the same example just used for ratios, a difference of one dollar between benefits and costs may mean a great deal more in a $5 transaction than in a million dollar transaction.

The other main criticism of ratios is that they ignore the absolute size of the numerator and the denominator. Thus, a benefit-cost ratio of 3 to 1 is the same whether it is $3 to $1, or $3 million to $1 million. In reality any policymaker is aware that much greater stakes are involved in some options than in others and takes this into account. With a benefit to cost ratio of 3 he will leap at the million dollar opportunity and ignore the three-dollar one; that is, unless the small one is an estimate of cost-benefit per unit and he is contemplating producing 10 million units at a cost each of $1 and a return each of $3. And again, the criticism applies to differences as well as to ratios. To know that benefit minus cost equals $2 is not enough; one must also know whether the transaction is $3 or $3 million. If it is $3 million the $2 difference is trivial.

Furthermore, cost-benefit differences require that costs and benefits be measured in the same units. Often this is difficult for social benefits or costs. Ratios on the other hand can be compared meaningfully even if the numerators have different units from the demoninators. For example, we know that 15 apples for $2 is a better deal than 20 apples for $5 even though apples and dollars are different units. In ratios, 15/2 is greater than 20/5. All that is required is that the two numerator scales be the same and the two denominator scales be the same.

As long as the policymaker is choosing among alternatives, and not trying to estimate the absolute payoff of each alternative, no standard unit of measure of utility is necessary. All that is needed is to know that Alternative A is expected to yield 1-1/2 times as much benefit as Alternative B and four times as much benefit as Alternative C, for example, regardless of what units benefit is measured in. This is the typical situation facing public policymakers in practice--weighing the relative value of alternative policies and outcomes, not estimating their absolute value.

They must choose among the available options for dealing with a problem, even if all options (including doing nothing) lead to an absolute loss of some magnitude. Their task in this case is to choose the lesser of evils. If benefits and costs are not measured in the same units, cost-benefit ratios would seem to give a clearer basis for choice than cost-benefit differences.

So far, we have argued the merits of ratios for comparing total utilities (benefits and costs combined) of alternative policies. Let us examine next how priority ratios make possible utility ratios.

A decision on how to allocate resources is logically based on three main inputs: priorities among objectives and unintended benefits, probabilities of success, and costs. Probability is a ratio by definition (the expected proportion of occasions on which an event occurs); costs are largely materials, labor, and capital which are easily expressed in monetary terms. Even social costs such as employee stress or pollution can often be translated into monetary terms by obtaining estimates of the amount of money that people would pay to avoid such costs. If priorities too can be compared on some ratio scale, the decision-maker has sufficient information to make clear-cut quantitative estimates of the relative benefits of alternative courses of action.

To illustrate the advantage of ratio scale of priorities over lower order scales of measure, consider the following example:

Plan A to achieve Objective A has a 90% probability of success and will cost $10 million.

Plan B to achieve Objective B has a 90% probability of success and will cost $9 million.

Suppose first that we have only an ordinal comparison of the priorities of Objectives A and B. If they are of equal priority or B is greater, policymaker has enough information to decide which plan will yield the higher utility. That is, Plan B is expected to yield equal or greater benefits at lower costs, so the total utility of Plan B is greater. However, if Objective A has greater priority than Objective B, the policymaker is stymied, for he has no way of knowing whether the difference in priority is worth the $1 million difference in cost, or worth only $100, or worth $100 million. An interval scale in this case provides the policymaker no more information than an ordinal scale.

The ratio scale of priority, however, provides the policymaker what he needs in order to calculate utility as the ratio of benefit to cost. Given that the best estimate of the benefit to result from a given plan of action is the expected benefit from achieving the plan's objective times the probability of success, we can calculate and compare the utilities of Plans A and B as shown in the the table below.

	A	B
Priority of objective (Benefit)	40	20
Probability of success of plan	.90	.90
Cost ($ million)	10	9
Utility	$\frac{40 \times .90}{10} = 3.6$	$\frac{20 \times .90}{9} = 2.0$

The example shown in the table assumes the priority of Objective A to be twice that of Objective B (40 vs. 20). By changing these relative priorities to different amounts, it can be seen that the utility of Plan A is greater whenever the priority of Objective A is at least 12% greater than that of Objective B. It can also be seen from this table that the units in which benefit is measured do not matter to the comparison of utilities as long as we are not interested in the absolute value of the utilities but rather only their relative size. That is, we do not care whether the utilities of Plans A and B were 3.6 vs. 2.0, or 36 vs. 20 since the unit of utility is meaningless. In either case the utility of Plan A is almost twice as great as that of Plan B. Thus, the unit of benefit does not matter as long as priorities of different objectives are compared as ratios on the same scale, whatever it be.

The example above shows the advantage of a ratio scale of priority over any lower order scale, in that it enables policymakers to compare utilities of different plans of action also on a ratio scale. To know that one plan has seven times as great a utility as another, for example, is more useful to a leader who must allocate resources than merely to know that one plan has greater utility than another. If the difference in utility were only 1%, then even though one plan had slightly greater utility, other uncalculated factors such as availability of personnel and resources would outweigh this slight difference in deciding which plan to choose. But if one has seven times the utility of the other, such factors of convenience would likely be put aside in order to choose the plan of greater utility.

The advantages of a ratio scale of measurement of priority become greater as the number of plans and objectives increases, for typically it will be unusual for a single plan to have both the greatest benefit and the least expected cost, the only situation in which ordinal and interval scales clearly indicate one choice.

Of course, the advantages of a ratio scale of priority hold true only if the user finds the scale meaningful and can make reasonably stable, consistent estimates. Most policymakers are familiar with ratio scales such as percentage, money and time, so that an adequate ratio scale is often feasible.

Direct Judgments of Priority

A person judging the priority of a particular objective may make a direct judgment on the dimension of priority itself. Or he may analyze the objective into a number of specific consequences and other related factors, evaluate these items separately, and then somehow combine them into an overall judgment of priority. The latter procedure is sometimes called decomposition, or disaggregation.

Several types of ratio scales have been used to get direct judgment of priority. One type is provided by answers to the question, "What would it be worth (in money) to achieve this objective?" or "What is the most the community should pay to achieve this objective?" Another approach is to assume a fixed quantity of resources (e.g., $10 million) to distribute among the various objectives.

The procedure lends itself to the use of mechanical aids such as washers, poker chips, or magnetic tape, which can be divided into piles or segments of various size representing different allocations. Such aids permit quick review of allocations by visual scanning so that adjustments can be made quickly. Techniques of this kind have been explored by other investigators (e.g. Webb, 1972, and Peterson, 1972) as well as by the authors.

The main advantages of direct judgment are its speed and economy. The main weakness is that the reasons or mental steps by which a priority is derived are not easily retraceable and there is no systematic accounting of specific factors relevant to the judgment. It could be argued that this presents no problem as long as different users show high agreement on the independent ratings of priority in the same policy situation. The assumption is that, whatever the reasons, if agreement is high there will also be high agreement on the implications of the priorities for policy. A counter argument is that the priority rating may be sensitive to the particular guidelines or the way in which the objectives are stated (Stake and Gooler, 1970). Thus, changing a few key words with evaluative connotations might greatly alter the perceived priorities of all raters. There is some support for this concern in the finding of many investigators (Fischer, 1972, Hammond, 1971, Huber, et al., 1969) that intuitive judgments tend to focus on very few dimensions, regardless of the decision-maker's intent to take many factors into account. A decomposition procedure which forces the person to examine each dimension and consequence separately may correct such errors, if the specific factors reviewed include those most important to the decision.

Decomposition Techniques

When judgment of the priority of an objective is decomposed into specific factors, the factors may be of many different kinds. For example, the priority of arithmetic skills as an educational objective can be analyzed in terms of the consequences of having those skills, such as providing for family more economically or success in a business enterprise. If each of these consequences has its own value more or less independently of what other consequences are achieved, then it makes sense to add the expected values of these consequences together to obtain an overall expected value of achieving the objective.

Another way of decomposing priority is to list the conditions which are jointly necessary for any value to be realized. For example, if arithmetic skills are to have high priority for an adult education agency, then the following factors must occur jointly:

1. There are positively valued consequences (e.g., success in business) which arithmetic skills are likely to help one achieve.

2. People do not already have the needed arithmetic skills.

3. Imparting these skills falls within the agency's realm of responsiblity.

Perhaps other conditions could be named as well, but the point is that each factor creates priority only to the extent the other two factors are also present. For example, if any of these three conditions is totally absent the priority of the objective would logically be nil for that agency. It is generally accepted that factors which interact in this way should be multiplied together to obtain an overall priority rating.

The simple example above illustrates the main stages of any decomposition procedure for setting priorities: deciding what components or factors the priority setters should consider; deciding what type of judgment should be made about each factor; and deciding how to re-combine the judgments of specific components into an overall priority rating.

Many studies have compared different mathematical ways of combining factor judgments into an overall evaluative rating (Huber, et al., 1971, Fischer, 1972). Results vary somewhat according to the type of breakdown but in general the results indicate that the mathematical method of combining matters little to the overall result, as long as one includes only methods that do not violate common sense. The final set of priorities or evaluations obtained correlate rather highly among nearly all such methods. The technique to be recommended here uses the simplest logical combination of rules, which turns out to be addition or multiplication depending upon the logic of the variables involved. But first, let us briefly review specific decomposition procedures developed by others.

Robert Stake (1972) developed a fairly simple procedure for use by school teachers and administrators who wish to set priorities among objectives. The basic philosophy of Stake's technique is that there are three or four types of factors which priority-setters should consider carefully, but that the way in which these factors are combined should be left to the intuition of each priority-setter. The factors to be considered for each objective listed are arranged in a matrix and include: the need for achievement of the objective as seen by the teacher, the learner, and the community; what resources would be allocated to the achievement of the objective; the probability that a specified allocation of resources would achieve the educational objective at a certain level; and contingency conditions which should be considered in the instructional process, such as what objectives are prerequisite to others. Stake's process of priority planning is quite broad and includes what we have defined as the total utility assessment, including allocation of resources.

There are many other variations of the matrix format in which objectives, or other outcomes are listed on one dimension and alternatives or factors which affect those outcomes are listed on the other dimension (Brown et al., 1974; Goeller, 1974). In each cell of this matrix is entered a quantitative or verbal estimate of the impact of that factor on that outcome. Quade (1975) reports much better reception by policymakers to scorecards or matrices which quantify only specific benefits and leave all the aggregation to the judgment of the policymaker. Other ways of setting priorities without quantifying the value of objectives on a numeric scale are discussed by Ellon (1972) and include: ranking objectives in order of preference and then optimizing them in sequence; and choosing only the most important goal while setting minimum acceptable levels of attainment for all other goals. Churchman et al. (1957) illustrate a procedure for weighting "intangible" objectives mathematially when the weight of tangible economic objectives is known.

Two techniques have come to our attention that used matrices to decompose priority and aggregated the elements mathematically to get an overall numeric index of priority. Cetron (1971) has described a "cross-support matrix" technique for priority setting in education. His matrix related educational and academic disciplies, such as agricultural science, economics and mathematics, to national goals such as agricultural productions, education and public works. By weighting the value of each goal and estimating the cross support among disciplines and goals, he obtains a "total relevance" score for each discipline as a measure of its priority. In the process he uses a quasi-logarithmic scale and transforms the results in a rather complicated and dubious manner, where a simpler linear scale might have served better.

The "relevance tree" technique is a similar matrix approach (Heneveld, 1970). It assumes two levels of objectives, the lower level objectives being related to the more general higher level ones. The technique is open-ended in that the user is asked to choose his own criteria of importance, such as economic urgency and cultural feasibility. Each objective is then rated on a numerical scale for each criterion of importance. These ratings are added together and combined with other factors (amount of change desired; relationship between lower and higher level objective) to obtain a final rating of priority for each lower level objective.

THE VALUE CONTRIBUTION (VC) TECHNIQUE FOR SETTING PRIORITIES

We developed the value contribution technique as part of an educational planning project in Indonesia, (Nichols, 1972) which included setting priorities among objectives. Existing techniques seemed inadequate, so we invented a new method which used ratio scales and spelled out the elements going into a judgment of priority so that they could be re-examined and justified later.

We called it the value-contribution technique because the basic kind of judgment on which it is built is estimation of the relative proportions contributed by various sources to some valued achievement. In staff tryouts, judging relative contributions to the total value of some achievement seemed more meaningful to staff than other types of value judgments on a ratio scale.

The fundamental formula in the VC method is $P = V \cdot D$, meaning that priority (P) of an objective is the product of its value when fully achieved (V) times the discrepancy between current and desired levels of achievement (D). Why do we multiply V and D rather than, say, adding them? Because an objective has priority only to the extent both V and D are jointly present. If either is zero no benefit can be expected. That is, if the value is zero the priority should be zero because the achievement has no value. If the discrepancy between ideal and current level of achievement is zero, then the objective is already achieved and the priority should be zero since no further improvement is expected. More generally, priority is directly proportional to value if D is held constant; any multiplication of value multiplies priority in the same ratio. The same holds true for discrepancy (D) if value is held constant. These assertions are based on the definitions of the variables, not on empirical data.

The value of an objective (V) is determined by its contribution to higher-order goals, each contribution being weighted by the value of the goal itself. Thus, if the objective, "can read," contributes to only one higher goal, the value of the objective is

$V = C_1 \cdot V_1$, where C_1 is the contribution of reading ability to Goal 1, and V_1 is the value of Goal 1.

Note again that we multiply the two factors because if either C_1 or V_1 is zero, the objective has no value in relation to that goal.

If the objective contributes to two independent goals, its value is $V = (C_1 \cdot V_1) + (C_2 \cdot V_2)$

For example, consider the goals:

Goal 1 = Has skills needed for useful, rewarding work.

Goal 2 = Enjoys diverse recreational pursuits.

Assume Goal 1 is four times as valuable as Goal 2, so

$V_1 = 4$ and $V_2 = 1$

Now let us assume these two goals are the only ones which the objectives "can read" and "can sing" contribute to, which is clearly not true but serves to keep the example simple. If reading contributes 9 times as much to Goal 1 as singing does, then

$C_{r1} = 9$ and $C_{s1} = 1$

If reading and singing contribute equally to Goal 2, then $C_{r2} = C_{s2} = 5$

(The contributions of all objectives must sum to the same total for every goal if C and V are to be independent; in this example the arbitrary total is 10.)

From the above, we calculate the value of reading to be

$$V_r = (C_{r1} \cdot V) + (C_{r2} \cdot V_2) = (9 \times 4) + (5 \times 1) = 41$$

and the value of singing to be

$$V_s = (C_{s1} \cdot V_1) + (C_{s2} \cdot V_2) = (1 \times 4) + (5 \times 1) = 9$$

Using the two goals in the above example makes it clear that values calculated for objectives will be good estimates only to the extent all goals served by those objectives are taken into account. Therefore it is important that the set of goals be comprehensive. However, knowing that human priority setters will never in actuality list every relevant goal and consequence of value, the VC method allows for a correction factor called R, which is the residual value of an objective beyond its contribution to stated goals. In arithmetic terms, R is the proportion by which V should be increased because of the objective's residual value. Thus if reading were judged to contribute to other goals besides #1 and #2 above, and this residual value amounted to 50% of its value in service to Goals 1 and 2 combined, then R would be .5 and the total value of the reading objective would be

$$V_r = 41 \times (1 + R) = 41 \times 1.5 = 61.5$$

In practice such a large value of R should suggest to priority setters that important goals have been left unstated and should be identified and added to the set of explicit goals. In applications by the authors to date the goals have been quite comprehensive, so the values of R for educational objectives have usually been zero and in no case greater than .02. The effect of R on priorities in such cases is negligible.

One other type of factor should be included in the final formula for calculating priorities, and that is limitations of ability to achieve the goals and objectives. In the case of a goal this means the extent to which achieving all the listed objectives is sufficient to achieve the goal.

For example, the goal of economic well-being for every person depends partly on being able to read and achievement of other educational objectives, but it also depends on health, family wealth and the local economy. If these other factors combined account for 40% of what it takes to achieve the goal, then only 60% can possibly be achieved by mastery of the stated educational objectives. Therefore in the priority equation the value contribution of all objectives to that goal should be reduced to .60 of C·V. If we call this "ability limit" factor "A," then the value of any objective (V_a) would be limited as follows:

$$V_a = (C_{a1} \cdot V_1 \cdot A_1) + (C_{a2} \cdot V_2 \cdot A_2) + (C_{a3} \cdot V_3 \cdot A_3) + \ldots\text{etc.}$$

In the above example, if economic well-being of a person is Goal 3, then

$$C_{a3} \cdot V_3 \cdot A_3 = C_{a3} \cdot V_3 \cdot (.6)$$

This completes the basic calculations of general priority of objective a, and we have

$$P_a = V_a \cdot D_a$$

Thus, if the value of the objective "can read" (V_r), is 41 (from an earlier example), and we wish 30% more youngsters to achieve it than now do ($D_r = .30$), then the priority is

$$P_r = 20 \times .30 = 6$$

Up to this point we have calculated the priority of an objective from the total community's viewpoint. But priorities for an agency within the community, such as schools, may be different because their responsibilities and capabilities are specialized and limited. For example, if learning to read is 90% within the ability and responsibility of the schools to achieve, then in calculating school priorities (as opposed to community priorities) the result should be reduced to 90%. Thus, the <u>educational</u> priority of the reading objective, using the numbers in the prior example, is

$$EP_r = 20 \times .30 \times .90 = 5.4$$

Or for any objective <u>a</u>,

$$EP_a = V_a \cdot D_a \cdot A_a$$

We use the same letter, A, as used earlier in denoting the limitation of ability to achieve a goal, because again the factor is a limitation of ability--in this case the ability of the agency to achieve the objective.

<u>Summary</u>. To summarize the above logic, the value of an objective (V_a) is estimated from its expected contribution to goals having different value,

$V_a = (1 + R_a)\ [C_{a1} \cdot V_1 \cdot A_1) + (C_{a2} \cdot V_2 \cdot A_2) + \ldots etc.]$, that is,

$V_a = (1 + R_a) \cdot \sum_g (C_{ag} V_g A_g)$, where "g" means "the sum across all goals."

The community priority of an objective is its value times the discrepancy between desired and current levels of achievement, $P_a = V_a \cdot D_a$.

The priority of the objective for a given agency is the community priority reduced by the agency's limitation of ability to achieve the objective. If the agency is the schools, then educational priority is

$$EP_a = V_a \cdot D_a \cdot A_a, \text{ or}$$

$$EP_a = (1 \div R_a)\sum_g (C_{ag} V_g A_g) \cdot D_a \cdot A_a$$

All factors on the right-hand side of the formula above are subjective judgments which may or may not be more valid and reliable then direct judgments of priority. But they do combine what would seem to be the basic ingredients of priority in a rational manner. Others who study the relation of priority-setting procedures to decision quality may well improve upon the above formula. From our perspective of the moment, it seems to be the most logical formula.

Illustrative Calculation of Priorities by the VC Method

The following example is a hypothetical case of one person setting priorities among 12 objectives which serve five community goals.

The community goals and their relative values are:

Judged Value	Goal
10	1. (Economic livelihood) All adults have sufficient income to live in moderate comfort.
8	2. (Self-realization) Each person has the opportunity and encouragement to realize fully his own potential as a human being.
6	3. (Social Harmony) There is social harmony among all groups and individuals most of the time.
5	4. (Nature) The natural environment of the community is pleasant, healthful and well preserved.
6	5. (Government) The governments which serve the community are efficient and responsive to all citizen's needs.

The goal values were derived by assigning the most valued goal an arbitrary value of 10. Each other goal was then given a value proportionate to the one valued at 10. As a check, the other 4 were compared with each other and the values adjusted until all pairs seemed to be in approximately the correct ratio of value. If the reader disagrees with these values or any of the other judgments made in this illustration, it may be worthwhile to recalculate values and priorities substituting his own judgments in order to get a sense of how the results vary according to such differences in judgment.

Suppose the school system in this community has adopted the following major educational objectives for its students, and wishes to set priorities among them so that it may be better prepared to plan and allocate resources:

Objective

a. Can read, write, listen and speak effectively in his native language.

b. Can communicate in a foreign language.

c. Has effective skills of study and inquiry, and enjoys learning.

d. Has acquired arithmetic skills and key concepts in mathematics.

e. Can effectively plan and manage his own time and resources, or those of a group.

f. Participates effectively as a citizen; contributes to community welfare.

g. Treats other people humanely and ethically; keeps commitments.

h. Develops own values and uses them to critically evaluate.

i. Appreciates humanity's cultural diversity and the common characteristics of human beings.

j. Cultivates expressive communication and appreciation in the arts, music and/or literature.

k. Understands the physical world and man's relations to it.

l. Maintains good physical and mental health.

The estimted contribution of each ojbective to each goal is shown in Table 1. The initial procedure used for each goal was to pick a highly contributing objective and arbitrarily call its contribution C = 10, then judge the other objectives' contributions in proportion: For example, being able to use one's own language well seems quite important to having a job, so it was assigned a C of 10 for Goal 1. The estimated contributions (Est. C) to each goal are shown in the left-hand column under each goal in Table 1.

The estimated C for each objective under a goal used an arbitrary reference value of 10 for convenience. The logic of the method requires that C sum to the same number for every goal. To achieve this the estimates of C were adjusted by a constant for each goal. The constant is computed for each goal at the bottom of Table 1, and the adjusted estimates of C in the "Total" row differ slightly from 60.0 only because of rounding error. All calculations in this illustration are rounded to 2 or 3 digits because the estimates are assumed to be no more precise than this.

Table 1. Contribution (C) of each objective to each goal

Short title for objective	Goal 1 Economic livelihood Est C	Goal 1 Adjus C	Goal 2 Self-realization Est C	Goal 2 Adjus C	Goal 3 Social harmony Est C	Goal 3 Adjus C	Goal 4 Nature Est C	Goal 4 Adjus C	Goal 5 Government Est C	Goal 5 Adjus C
a. Own language	10	8.6	8	5.9	4	4.0	3	2.9	8	5.8
b. Foreign language	1	0.9	5	3.7	4	4.0	1	1.0	2	1.5
c. Inquiry/learning	8	6.9	10	7.4	4	4.0	6	5.7	10	7.3
d. Math	6	5.2	2	1.5	0	0.0	1	1.0	5	3.7
e. Plan and manage	11	9.5	10	7.4	3	3.0	6	5.7	7	5.1
f. Citizenship	2	1.7	5	3.7	8	8.0	12	11.4	14	10.2
g. Treat others well	7	6.0	3	2.2	10	10.0	5	4.8	9	6.6
h. Own values	3	2.6	9	6.7	5	5.0	2	1.9	8	5.8
i. Humanity	3	2.6	6	4.4	9	9.0	4	3.8	8	5.8
j. Arts	2	1.7	9	6.7	5	5.0	1	1.0	1	0.7
k. Physical world	5	4.3	4	3.0	3	3.0	12	11.4	6	4.4
l. Health	12	10.3	10	7.4	5	5.0	10	9.5	4	2.9
Total	70	60.3	81	60.0	60	60.0	63	60.1	82	59.8
Adjustment Factor	$\frac{60}{70} = .86$		$\frac{60}{81} = .74$		$\frac{60}{60} = 1$		$\frac{60}{63} = .95$		$\frac{60}{82} = .73$	

Next we estimate the extent to which each goal can be fully achieved by achievement of the 12 stated educational objectives. This judged limitation (A) is shown for each goal in the first column of Table 2. For example, "economic livelihood" is judged to be only 60% achievable through these 12 objectives above, while "self-realization" is judged to be 95% achievable through these 12 objectives.

For each objective the product of V and A (that is, V·A) is then multiplied by the contribution (C) of the objective to that goal. The right-hand side of Table 2 illustrates these calculations for one objective (a. own language). The contribution of Objective a for all 5 goals together is the sum of the CVA, which is Σ(CVA) = 156.

Table 2. Ability limits (A) and values (V) of each goal and calculation of the value of Objective a.

	Goal	A	V	V·A	X	Ca	=	CVA
1.	Economic livelihood	.60	10	6.0	X	8.6	=	52
2.	Self-realization	.95	8	7.6	X	5.9	=	45
3.	Social harmony	.85	6	5.1	X	4.0	=	20
4.	Nature	.75	5	3.8	X	2.9	=	11
5.	Government	.80	6	4.8	X	5.8	=	28
				Total, or Σ(CVA)=				156

By the same formula, Σ(CVA) has been calculated for each of the 12 objectives and the answers are shown in the first column of Table 3. The remainder of Table 3 shows the final calculation of the educational priority of each objective. In preparation for this calculation the residual values (R) of each objective were estimated. If "plain unconstructive fun" had been included as a goal, most of the residual values would have been much smaller. In the case of "math" the R of .25 is attributed mainly to the practical convenience of math around home, shopping, banking, etc., which are not included in the 5 stated goals.

The column to the right of R is the total value (V*) of the objective, including the R factor. For example, the value of objective a was increased by 15% from 156 to 179 because R = .15. The next column is D, the discrepancy between desired and current actual proportion of youth achieveing the objective. For objective b the desired level was .50, meaning half the graduates should know a foreign language, and the current level .10 yielding a D of.40. For objective j (arts) the desired level was .90 and the current level .40 yielding a D of .50. For all other objectives the desired level was set at 1.00, meaning all youth should achieve it, and the D shown is the difference between 1.00 and the proportion estimated to be achieving the objective currently.

The next column in Table 3, labeled A_s, is the factor reflecting the limitation of the schools' ability to bring about full achievement of each educational objective. These judgments reflect the schools' responsibility and the state of the art of teaching, but not current flaws in the local schools which could be corrected by appropriate action within a reasonable time. A_s is near 1.0 for math (Objective d) because the schools have the responsibility and ability to achieve it. On the other hand A_s is only .30 for "Treat others well" (g) because that objective is judged to depend mostly on factors outside school.

Finally, educational priority (EP) is the product of V, D and A_s. Priority for the community is simply $P = V \cdot D$, as noted earlier. But to obtain educational priority we must multiply priority by the school's ability to achieve each objective. Thus $EP = V \cdot D \cdot A_s$.

Table 3. Calculation of educational priorities (EP) of objectives

Objective	Σ(CVA)	R	V*	D	A_s	EP
a. Own language	156	.15	179	.35	.85	53
b. Foreign language	65	.20	78	.40	.95	30
c. Inquiry/learning	175	.15	201	.70	.80	113
d. Math	64	.25	80	.50	.95	38
e. Plan/manage	175	.20	210	.55	.60	69
f. Citizenship	171	.05	180	.80	.60	86
g. Treat others well	154	.20	185	.30	.30	17
h. Own values	127	.20	152	.40	.50	30
i. Mankind	137	.20	164	.45	.75	55
j. Arts	94	.20	113	.50	.60	34
k. Physical world	128	.10	141	.30	.75	32
l. Health	194	.35	262	.50	.40	52

* Total value of an objective, $V = (1 + R)\ \Sigma\ (CVA)$

The superintendent of a school district who arrived at the above priorities might find some surprises. Inquiry techniques, love of learning and citizen skills are frequently paid lip service, but to find that their priorities for action are from 1 1/2 to 3 times as great as nearly all other objectives puts them in a new light. It might lead the school district to search harder for ways to achieve these objectives and perhaps to invest more of the school dollar in them.

Priority-setting by a Group. Setting priorities for a community or society is a task seldom delegated explicitly to one person, though one person often controls the process temporarily by default. More often a group of elected and/or appointed officials determines priorities, and usually does so implicitly through its action decisions rather than by setting priorities as a distinct task in itself. For policy-making groups undertaking the explicit task of setting priorities, methods of achieving consensus must be considered.

Sen (1970) has discussed the problems of aggregating personal utilities into a collective utility, which is equivalent to aggregating priorities. Arrow (1963) concludes that utilities cannot be compared between persons, but does so apparently on theoretical and philosophical grounds. In a more practical vein, Van de Ven and Delbecq (1972) have recently summarized the evidence concerning what types of decisions are best suited to different types of group processes. They distinguish between interacting groups and nominal groups, in which members do not interact with each other. On the basis of the available evidence, they recommend that nominal group processes are better for fact-finding and idea generation. For a number of reasons an interacting group inhibits many of the members and suppresses creative thinking. Nominal groups, in which individuals work alone, tend to excel over interacting groups (including brain-storming groups) in the quality, quantity, and variety of ideas produced. They also suggest that time may be used more economically in nominal groups since tasks can be started and stopped more quickly.

When the task of a group is to synthesize information or work toward consensus in evaluation, the research suggests that interacting group processes are at least as effective as nominal group processes. It would appear that priority-setting emphasizes the tasks of synthesis and reaching consensus more than it does creative generation of ideas. On this basis either interacting or nominal groups or some conbination might be appropriate to the task of setting priorities.

However, there is a substantial body of evidence confirming that the judgments of individuals are strongly influenced by the judgments of other members of the same interacting group. In view of this it would seem sensible to obtain independent judgments from the members of a priority-setting group first, so that the initial range of disagreement could be estimated accurately. Afterwards, group discussion might be used as a basis for reaching consensus. This is the procedure recommended by Huber and Delbecq (1971) for practicing managers of decision conferences, and is the principal which underlies some uses of the Delphi technique (Helmer, 1966). Most applications of the Delphi technique involve repeated cycles of individual judgments in nominal groups, with summary information about judgments and reasons displayed anonymously to each person.

If a group planning to use the VC method is not too large we recommend that a modification of Delphi technique be used to arrive at a single group estimate of each factor. That is, each member begins by independently making his own estimate of the factors from whatever evidence is on hand and his own experience and values. After these are recorded the group accepts the group average (mean) if there is close agreement on a factor, but discusses reasons for their judgments wherever there are sizable discrepancies. If the discussion yields a clear consensus, this is accepted as the group estimate. If consensus is not clear, another record of independent individual judgments may be taken and again reasons for discrepancies discussed. If substantial disagreements persist, a group average is accepted and the more discrepant individual estimates are appended to the record so that the sensitivity of the results to these differences may be calculated.

The size and composition of groups appropriate for priority-setting must depend in part upon the range of knowledge and expertise required to make the individual judgments competently. Huber and Delbecq suggest that, in general, adding members beyond the group size of 10 seems to contribute little to the reduction of judgmental error. Large interacting groups also tend to take longer to complete a given task and represent larger expenditures of man-hours of effort. If larger groups are needed in order to represent the full range of expertise needed, it may be better to divide the task into subgroups or committees approximately 10 members in size, with a coordinating committee to combine the work of the various subgroups.

Since the time which skilled personnel have available to set priorities is limited, it is important that their time be focused on those parts of the procedure which have the greatest impact on the final priorities derived. The parts having greatest impact are defined as those steps in which variations in human judgment make the greatest difference in the numerical priorities which result. Estimating contributions of objectives to goals takes the most time and each separate judgment has the least impact, so it may be hastened by delegating the task to smaller subgroups or individuals. To the extent that different members of any group are differentially knowledgeable about different goals or objectives, the task can be divided among subgroups so that each member concentrates on those areas where his expertise is greatest. When time is critical the task can also be speeded up by allowing wider limits of disagreement for accepting a group consensus estimate without further discussion. Also, most of the arithmetic calculations in the VC process can be completed by a clerical assistant while priority setters are completing their estimates.

When a higher level group is reviewing the work of a sub-committee staff group, time can be saved if each reviewer first independently reviews the values estimated by the staff and circles any values that he disagrees with by a substantial margin (say 20%). If a clerk tallies a list of the items circled by one or more reviewers, discussion can then be limited to those few items. Twice in the Indonesian application higher level government officials reviewed staff estimates, and in both cases the number of changes resulting from a fairly thorough review was very few. Although there may be cultural differences, this suggests that adding the review process may not change the final priorities much.

Beyond small face-to-face groups, many studies of objectives, needs, and priorities have involved collecting judgmental data from larger samples of people from appropriately defined populations. Stake (1970) has reviewed the status of this research. In many educational needs assessments in the United States in recent years samples of students, parents, educators, and other citizens have been asked to rate a list of objectives or needs on some type of scale. Typically these individual judgments have then been combined statistically to obtain an index of priority.

Another approach, using the critical incident technique (Abbott et al., 1968), involved collecting thousands of specific accounts of incidents which demonstrated effective or ineffective education of youth in a particular school distirct. These incidents were then categorized into community concerns as a basis for later development of instructional objectives. It is tempting to define educational priority by the number of citizens who mentioned incidents in a particular category of concern, but this is probably not sound. The number of behaviors reported in a category of concern may well reflect the salience of this category in the public mind, but the above study suggests that it does not reflect perceived importance or educational priority; a sample of citizens rated the importance of the categories and the product-moment correlation between salience (number of incidents) and rated importance was only +.16, indicating at most a weak relationship between salience and rated importance.

Applications of VC and other Ratio Techniques

The initial application of the value-contribution technique in Indonesia is described in earlier reports (Nichols, 1972; Campbell, 1974). Subsequent applications in the Philippines are described by Jasin (1973). The Indonesian and Philippine reports both detail specific problems and recommended solutions in setting priorities. The following comments were made at a Southeast Asian Conference on primary education by Sudijarto (1974), a high ranking educational official in Indonesia who was mainly responsible for our priority setting efforts there.

"Before the first Five-Year Development Plan, politicians wanted 1% to 1 1/2% of the population to complete university, and the result was that almost all money was put into the universities. It was not until we started using some of these priority-setting techniques that we realized how poorly we were using our resources. Beginning with the first Five-Year Development Plan we started to allocate our resources differently."

In the Philippines Jasin compared empirically two variations of the value contribution method of setting priorities with the method of estimating priority ratios directly. They streamlined the VC technique and reduced calculations to the key variable "value." The four techniques of computing value ratios that they tried correlated quite highly (part-whole correlations of .76 to .88), even though entirely different groups of persons used the different techniques. This gave them more confidence in the overall approach of using ratio judgments. They concluded that although simple, direct estimates of value were the quickest, the safest procedure was to use a relatively simple variation of the value-contribution technique so that the basis for judging value could be analyzed and retraced, and those making the judgments would have to focus their attention on specific goals and on ways objectives contributed to these goals. The reports above also include a number of practical recommendations on training in use of numerical scales, number of persons in a judgment group, and number of specific objectives within a more general objective.

Another factor in priorities which has been dealt with in various ways in different applications is the extent to which an objective can be achieved through formal schooling. The ability of schools or any other institution to achieve an objective has been built into our earlier formulas for priority as a quantitative factor. Jasin has dealt with it as a separate qualitative consideration after value was calculated. This has some real advantages. The main one is that priority should be considered first of all as a general matter for the whole society. If each agency, such as schools, religious institutions, law enforcement, and other agencies, calculates its own priorities separately, many important objectives may be omitted from the high priority list simply because no one agency clearly feels it has responsibility for achieving that objective. Therefore it is probably best to consider priority as a general matter and decide afterwards which agencies and institutions should cooperate to achieve the objectives.

CRITIQUE

The art of setting priorities is clearly still in its infancy. Our techniques are tentative, and the few analysts who deal with priorities quantitatively do so experimentally, changing this or that feature to see what works best. Different problems call for different analytic structures, of course, and clients vary greatly in attitudes toward decomposition and quantification.

The main obstacle to wider application of decomposition techniques has been their complexity. As long as rapid intuitive judgments on priorities are accepted uncritically, policymakers will tend to follow this more expedient and economical habit. The value-contribution method of setting priorities is as simple as we could make it without ignoring vital realities. Everything but estimating the factors is easily automated. Still, the number of human estimates required may seem too large an effort to most policymakers until there is substantial pressure for specific justification of decisions and priorities.

One of the advantages of the techniques such as VC is that the many steps by which priorities are derived are explicit and retraceable, so that those who disagree with a given priority and wish to locate the specific judgments which account for the disputed priority can do so. In this way public policymakers can justify their decisions by making public the detailed set of steps and judgments on which a decision was based. This can add appreciably to the trust among various levels of public authorities and to the credibility of public interest as the primary consideration in public decisions.

The applications of the VC technique described here assume public interest to be the total value base. The technique could just as easily include other values such as profit or power, which would be more appropriate for business and other competitive enterprises than for a government which exists only to serve its people. Of course other motives such as personal gain often do influence public decisions, and those who wish to predict or describe the actual behavior of decision-makers probably improve their accuracy by taking such motives into account. But if the intent is to set priorities in a way that best serves the public interest, then it is appropriate to consider only public goals. This does not deny that public authorities have personal motives as well. It means only that they are utlimately accountable to the public. And with an ever more alert citizenry leaders will likely be called on to justify their priorities in terms of the public interest, no matter how they set priorities personally.

The main source of variability or unreliability in setting priorities by the VC and related methods may lie not in the calculations nor in the estimates themselves, but in the prior task of specifying objectives and goals. If important objectives or goals are omitted and dont't come to mind in estimating R, the priorities may vary appreciably. Conversely if two goals overlap so that some of the same achievements are included in both, the resulting priorities will be biased in the direction of overestimating the importance of those achievements. These weaknesses in goal and objective statements can be minimized by weeding out redundancy at the start, and by a thorough review of the statements for important omissions.

The priorities derived by the VC technique are numerical estimates of expected benefit and can be compared as ratios. As noted earlier this means that cost-benefit ratios can be calculated and compared for different policy alternatives. The rational decision maker can thereby arrive at a clear decision to the extent he trusts the method and the inputs. If the trust is low he can weigh priorities, costs and feasibilities subjectively, along with other factors, in arriving at a final decision on allocation of resources. It is important that analysts deal openly and honestly about the uncertainties of estimates and quantitative formulas. Policymakers can accept these uncertainties better if they understand the key principle that a rough approximation which accounts for important uncertainties is far more useful than a precise answer which ignores them. Whatever the actual basis for a decision, we strongly recommend that an accurate record be kept of the specific decisions made, along with the calculations of priorities, costs and probabilities of success, so that later comparisons of the relative outcomes of quantitatively and qualitatively based decisions are possible.

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