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ABSTRACT

To insure that information needs are met or identified and that these needs are communicated to information producers in a systematic way, a sensing network is proposed for monitoring information system operation and forecasting information needs. Concerns of the network and bases for evaluating the information system are identified. Five staff teams are suggested for the system and their duties described. Ten criteria to be used to evaluate the information and the information system are listed. Methods of extrapolating, scenario writing, and morphological analysis as means of understanding future information needs are explained. (SK)

"The Design of a Future-Oriented Sensing System for the Identification, Production, and Dissemination of National Educational Information Needs"

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I. CURRENT STATUS

A great deal of effort, at the Federal, State, higher education and local school district levels, has been expended toward developing educational information systems. These efforts have been supported largely by OE and to a limited extent by NIE. A review of these systems supports the conclusion that much has been accomplished and yet none of these systems has succeeded very well in supporting decision making processes at different levels in the education network and impacting effectively educational practice and research.

In reviewing the status of information systems, five conclusions are reached:

1. No really successful educational information system has been developed to date
2. The singular, "information system," is misleading; there are a wide variety of information users with a variety of quite disparate decision responsibilities, and therefore a wide variety of information needs. It is unrealistic to expect that a single "information system" will serve the entire educational community
3. Information system design involves formidable issues of synthesis because of the multiplicity of relevant variables which are interconnected in poorly understood and probabilistic manners
4. In the areas of educational information systems, there have been far more failures than successes
5. The future poses a set of problems far more complex than have been faced to date.

The purpose of this paper is not to reiterate the needs or purposes of educational information systems, but rather to propose a mechanism for monitoring information system operation to insure that information needs are met or identified and that these needs are communicated to information producers in a

systematic manner. This paper presents such a paradigm and discusses methods of information needs forecasting.

II. SYSTEM CHARACTERISTICS

The need for the design of a sensing network is concerned with: monitoring information requirements of the educational community, determining measures of information needs, and employing measures on a constant or recurring basis to keep needs data up-to-date. This statement implies that the sensing network must continually be monitoring needs and insuring that the needs are communicated to information delivery system personnel and to potential information resource producers. It has been pointed out that the sensing network must also be concerned with projecting future information needs and assuring that these projected needs are communicated to potential information producers. It is critical that the sensing network have a future orientation as well as a present orientation.

Perhaps the greatest weakness in most information systems is the lack of concern for a feedback mechanism which leads to changing the information dissemination system and insuring that future information needs are made known. Collecting information-needs data from users and potential users is important, but there must also be a major effort to collect information from producers and potential producers, so that the discrepancy between needs and the likelihood of the needs being addressed by information producers can be estimated.

The implementation of a sensing network serves as the basis for evaluating the information system in terms of:

1. Monitoring the effectiveness of meeting current information needs, based on specific criteria of effectiveness
2. Determining information needs that are not being met

3. Determining information resources that are not incorporated in the information system
4. Assessing alternative strategies for reducing the discrepancy between needs and resources
5. Monitoring the process of making system up-dates and revisions
6. Projecting information needs and potential sources.

The proposed sensing system provides the interface between the information user and the information producer. Figure 1 graphically describes the sensing system.

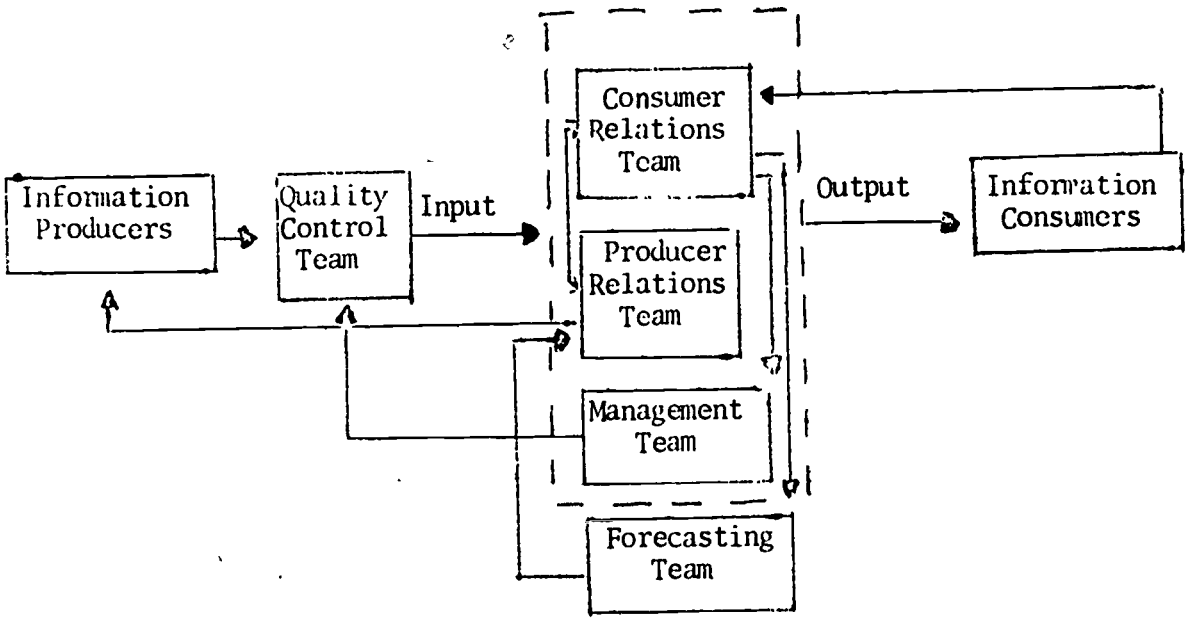

Figure 1. Sensing System Structure

Five staff teams are needed for the sensing network of the information system.

1. Quality control team - responsible for evaluating potential information resources for inclusion into the system (assumes task of analysis of information resources)
2. Consumer relations team - responsible for assessment of educational community information needs (assumes task of determining resources)
3. Producers relations team - responsible for working with information producers to facilitate production of identified information resources to meet current and projected needs (assists with task analysis of information resources)
4. Forecasting team - a group of educators and social science experts responsible for projecting future information needs and potential producers (assists in both tasks mentioned above)
5. System management team - responsible for monitoring the use of the system in terms of costs of data collection, internal system design, system time responsiveness, and costs of internal system functions.

The coordination of the efforts of these teams is essential. Thus, a sensing network coordinator would be required and should be a high-level staff administrator.

Information quantity is presently massive and is increasing at an almost exponential rate. It is therefore essential that information units be evaluated prior to inclusion in the system and again as they are used in the system, on a recurring basis. Criteria which may be used to evaluate information system input and output are ones specified by the Phi Delta Kappa National Study Committee on Evaluation. They are slightly modified to be used in this application.

Criteria to be used to evaluate the information and thus the information system would be:

1. Internal validity - extent to which specific information corresponds to phenomena represented, extent to which descriptors are accurate
2. External validity - extent to which specific information is generalizable to situations where information is needed
3. Reliability - extent to which information is stable, extent to which system provides consistent types of information in response to similar requests
4. Objectivity - extent to which information user is provided with information which is interpretable
5. Relevance - extent to which information user is provided with information relevant to his purpose with minimal redundancy and minimal irrelevant information
6. Importance - extent to which most important information available is provided to user
7. Scope - extent to which information is not too narrow or broad for intended purposes
8. Credibility - extent to which information comes from a credible source and is trustworthy
9. Timeliness - extent to which information is provided to user with minimal response time
10. Pervasiveness - extent to which information users are aware of existing information resources and the capabilities of the system to provide useful information in a format and in time for use by educational decision makers

11. Efficiency - extent to which system is sensitive to information needs of various user groups and is efficient in providing information resources

12. Cost-effectiveness - extent to which system provides needed information at lowest cost in terms of personnel time, processing time, output formats, etc.

Each of the teams would be responsible for various evaluation efforts:

			Team		
Evaluation Effort	Quality Control	Consumer Relations	Producer Relations	Fore-casting	System Management
1. Internal Validity	1	2	2		
2. External Validity	1	2	2		
3. Reliability	1	2	2		
4. Objectivity	1	2	2		
5. Relevance	2	1	1	1	2
6. Importance	2	1	1	1	
7. Scope	2	1	2		2
8. Credibility	1	2	1		
9. Timeliness	2	1	1	1	1
10. Pervasiveness	2	1	1		
11. Efficiency	2	2	2		1
12. Cost-Effectiveness					1

1 - Primary responsibility

2 - Secondary responsibility

Multiple indices would have to be identified and observed in the evaluation of the system through the sensing network. Each of the sensing network teams would devise data collection mechanisms and analysis procedures congruent with their functions.

Much information on resources and needs would be available through the procedures and results of pre-implementation planning. Those methods and results will be assessed for incorporation with the sensing network.

Information collected and used in the identification of roles and effect of those involved in educational policy determination, practice, research or development would be described in terms of sampling methodologies, survey measurement techniques, and statistics regarding frequency of usage of specific types of information by specific audiences identified in an audience typology. This documentation would be the primary responsibility of the Consumer Relations Team with the assistance of the Sensing Network Management Team. Current information elements would be costed-out in relation to costs of input into system, data aggregation (if necessary), storage, retrieval, and dissemination. This activity would be the responsibility of the Management Team.

On the basis of a report prepared describing the market survey procedures, the Consumer Relations Team and the Forecasting Team would evaluate the procedures to determine the discrepancy between information needs and current market resources. Priority areas would be identified and discussed with the Producer Relations Team in order to develop strategies of reducing information needs-resources discrepancies.

It is not reasonable to assume that needs assessment can be done on a global scale covering all user types and information utilization needs by using the same sampling and data gathering techniques. Once a user typology is determined data needs, sampling plans and data collection instruments and/or techniques would be specified. A assessment would then be made regarding duplication of data collection efforts and the feasibility of methods.

The Consumer Relations Team and the Producer Relations Team would formalize interface mechanisms to insure that current priority information needs can be determined and met, and that future needs can be predicted based on the work of the Forecasting Team.

The identification and description of alternative methods of needs assessment would be a primary function of the Forecasting Team with the assistance of the Consumer Relations Team. The Forecasting Team would be a group of education and social science experts who would use information provided by the Consumer Relations Team to predict future information needs and determine alternative needs assessment strategies. This group should involve industrial philosophers and technical experts. The techniques of extrapolation, scenario writing, Delphi methodology, and morphological growth analysis should be considered as potential methods of needs assessment. Another important aspect of this work is the evaluation of "guiding predications" as (1) how we can have more knowledge about the future, (2) relating predictions to action, (3) predicting our values, and (4) identification of errors in prediction.

In addition to this activity, the Management Team would develop non-survey indices of the utilization of the system. Predications would be made regarding the areas of education which will tend to increase in activity and areas which will tend to decrease in activity. This information would be presented to the Consumer Relations Team and to the Forecasting Team to determine validity of trends of information usage.

The Producer Relations Team would maintain a file of information producers categorized by areas of information topic areas. These data could be used to make predictions of increases or decreases in the quantity of specific types of information production.

3. "Morphological" analysis which systematically considers all logical information uses in a defined system.

1. Extrapolation

This method consists of predicting for the future a continuation of trends which have been observed in the past. It is a projection of empirically observed trends using known mathematical models where possible.

Suppose, for example, we devise some measure and are able to determine for each of the past 20 years the amount of information on new educational products used by the average classroom teacher in guiding his or her instructional activities. The amount of information will undoubtedly have increased because the demands of teaching continue to grow as society becomes more complex, and the number of available educational products has increased.

What is the nature of the increase, however? Can it be defined as a simple linear function as in Figure 2A? Is it an exponential curve as in Figure 2B, or a logistic curve as in Figure 2C?

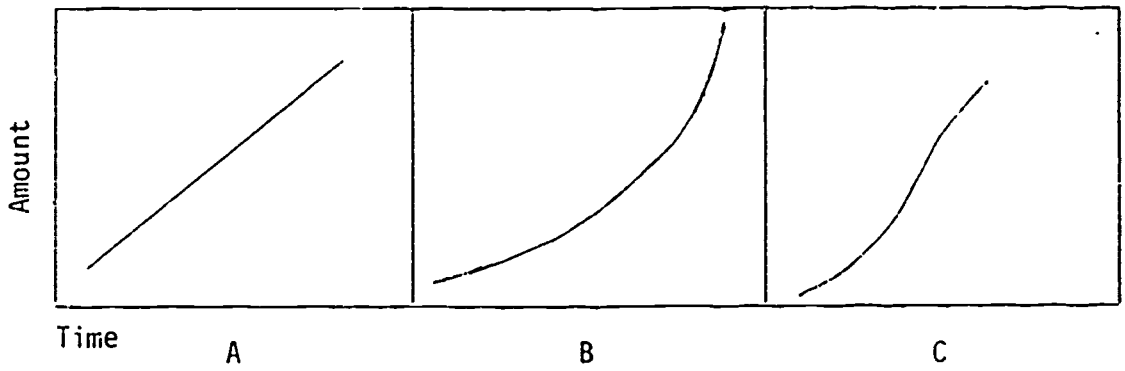

Figure 2. Possible Information Use Curves

Now to use extrapolation in the forecast of future needs for this type of information, we will continue the form of the curve which we decide is appropriate. One can, in fact, generate an area of expectation by altering the parameters of the curve. It may be, for example, that the curve currently appears to be exponential, but that we are not willing to assume that it will continue in this fashion. We may make various estimates of where inflection points will occur, and where the curve will become logistic. This generates the type of forecast shown in Figure 3 where we have different forecast areas within the extrapolated curve. Now if we take the two extremes as the ones we feel certain to, say, 80 percent that the actual range will lie within, we have a probability area of considerable confidence.

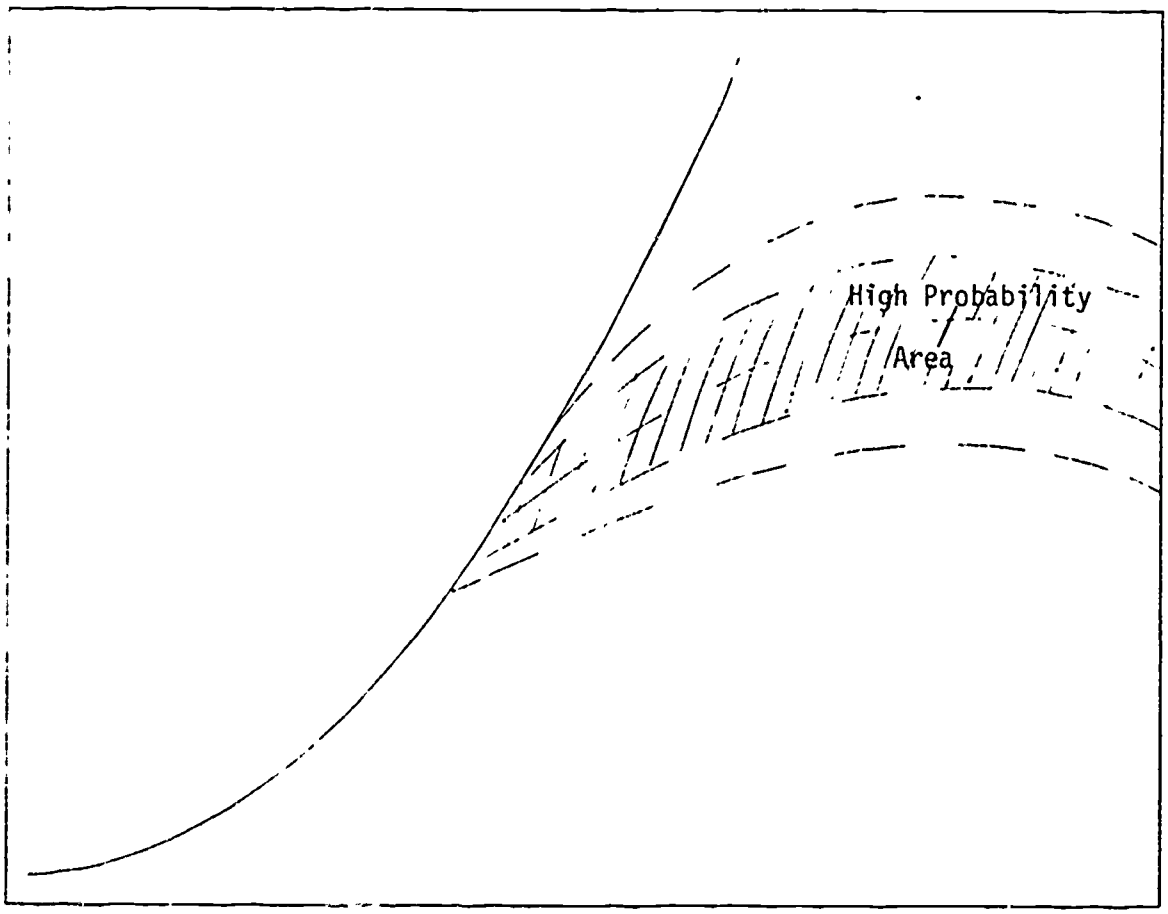

Figure 3. Probability Space Related to Different Inflection Points

This type of extrapolation can be used with each type of educational information or it might be used with some combination of the total of the educational information needs. It is a valuable method because, in fact, the future is a continuation of the past, and trends are not likely to change radically in the immediate future. The difficulty lies, however, in the inability of this method to take into account major environmental or historical changes which may, in fact, effect the use curve in ways not accounted for in the past.

An interesting example of this kind of error-producing phenomenon is the current over-supply of trained teachers in the United States. During the decades following World War II, there was always a teacher shortage. As the population continued to increase, larger numbers of students entered the schools each year, and the teacher training institutions were simply not geared up to meet the demands. They continued to enlarge their capability, and to act as though the increase in population would continue indefinitely. In the 1960's, however, the downward trend in population increase began to show as the birthrate declined. No tremendous amount of insight should have been needed to see that the result within a predictable time would be a lower rate of growth of school populations, and in time there might even be an actual decrease in school populations. As a result, a smaller number of teachers would be needed in the future. Teacher training institutions in general ignored this kind of evidence, however, and simply extrapolated future needs from the experience of the 20 years after World War II. Now we have the out-of-kilter time problem; we have large numbers of teachers who cannot find jobs.

This example indicates that, while extrapolation is a very valuable way of getting an estimate on what outcomes one might expect in the future, it has certain weaknesses and needs to be complemented by other projection methods.

2. Scenario Writing

A second approach to forecasting future information needs is to seek the opinions of and develop consensus among the leading experts in the interest area. For example, one hundred persons across the country, who are respected for their knowledge about how education operates and about how information is used and should be used, might first be queried on their own opinions on what changes in the general society are likely to occur in the future, what changes in education itself are likely to result from this, and on how all of these changes are likely to effect the needs for information in education.

Knowledgeable people may expect, for example, that in the years ahead computer technology will be developed to the point that some type of computer-assisted instruction or computer-managed instruction is likely to become central in the educational process; that, for example, such developments as holography are likely to make instruction using computers in different ways much more effectively than today. There may be important new developments in educational television, for example. The current requirement that future cable systems have two-way channels dedicated to education could have tremendous effects on the way that educational experiences are delivered. The tremendous growth of the so-called knowledge industry is likely to have radical effects on the education needed by persons before they begin their careers and as they proceed through careers.

This type of knowledge can be brought into effect by the "experts" in determining what information needs are going to be in the future, and the result will be more insightful and "informed" than that produced by pure extrapolation.

After leading issues are identified and opinions expressed, some method of setting up dialogue, of reconciling differences, and of achieving consensus is needed. OECD used a set of Delphi surveys in its work. In the Delphi process, major questions are first identified. Then the expectations of each participant in regard to major issues are determined. The results are aggregated, central tendencies and variances computed, and the outcomes fed back to the participants.

This process can be carried out so that, at various points, participants can give their own arguments and reasons as to why they make their own choices, and in this way the reasons for differences can be understood and dealt with. At some point, a second round of voting, compiling results, and feeding back occurs, and the cycles can be repeated. Usually consensus develops--there is a coming-together of opinion as the different persons see the reasoning and responses of their fellows.

There are many different audiences for educational information, of course, and many different information types. Few persons are likely to be expert in all aspects of the field. Rather, there will be groups of experts who know about different parts. It is likely, therefore, that several surveys will be needed.

Based on conditions the experts agree are likely to hold, various scenarios of different aspects of the future can be built. The underlying assumptions can be changed to some extent to reflect uncertainty, and, as with extrapolation, the end result will be areas of probable outcomes.

Generating scenarios of the future based on expert opinion has some obvious advantages over simple extrapolation. As we said, the experts presumably have some notions of the kinds of influences which are likely to be brought to bear which do not now exist. They can bring in their other special human qualities and insights which are never included in any mathematical equation.

The weakness, of course, is in that even the experts are often wrong. Conditions occur which they do not anticipate, and experts, like the rest of us, are often captives of their own knowledge of the past. Also, it is often difficult to think at the level of complexity at which life exists. Experts may fail to think of the total range of influences, and they may neglect important interactions among influences.

3. Morphological Analysis

The third approach to forecasting uses what OECD calls "morphological analysis." This approach considers information as a basic resource rather than as knowledge or as input and output in the R&D sense. In this context, information is defined formally as an essential link between activities, of which there is a large variety, both intellectual and material. Information is a resource which, like other resources, must be made available and utilized for progress to occur. The problem is to identify where the need for this resource, that is, for linkages, is going to be.

In following this approach, one looks systematically at all of the types of linkages (that can now be identified) that may occur. This involves first of all identifying the classes of possibilities and constraints which may

apply in general in education in the future, and then looking at elements within the classes. By listing these and systematically considering information linkages which may exist among them, a wide range of possibilities of information need can be generated. This set of possibilities may, in fact, be quite different from those shown through either the extrapolation method or the scenario method.

Suppose, for example, that the generic categories of possibilities and constraints in education include objectives, tools, institutions, resources, values, and individuals. Suppose further that the generic categories are subdivided as follows:

Objectives

- Quality of Life
- Standard of Living
- Availability of Alternatives
- Liberation
- Participation
- Space

Tools

- Concepts
- Models
- Theories
- Explanation
- Utilization Analysis
- Forecasting
- Control

Institutions

- Early Childhood Education
- K-12 Educational Institutions
- Higher Education
- Community and Continuing Education
- State Departments of Education
- U. S. Office of Education

Resources

- Technology
- Programs
- Physical Science
- Social Science
- Information
- Telecommunications

Values

- Political Authority
- Economic Authority
- The Social System
- Ideology
- Equality
- Coercive Authority

Individuals

- Students
- Teachers
- Parents
- Researchers
- Administrators
- Multi-Disciplinary Teams

The question becomes, what kind of linkages are required between the elements of these generic categories. A linkage in this case implies an information need. There may be a link, for example, between quality of life and the work of the multi-disciplinary teams. In fact, this set can be shown graphically as in Figure 4 as six hexagonals, each representing a generic category, and the points of each hexagonal representing a sub-category.

Connecting all points within the hexagonals and between them generates the full range of possible linkages. In this simple model, there are 630 theoretically possible combinations.

In reality, the system is much more complex than this, and there are literally thousands of links to be explored and decisions made as to the likelihood of their being important in the future. Computer help with this kinds of analysis is probably necessary since the range of possibilities is so large. Following through with the method, however, provides a very specific and comprehensive way of examining all possibilities which, to the best of our current logic, may occur in the future. At the conslusion, probability areas can be constructed.

4. Making the Forecast

Following through with all three types of forecasting methods, we will have three areas of probable outcomes for the future. The question now becomes the degree of overlap among them. All three methods have strenghts, and all three have areas where they can be in error. It seems reasonable and logical, however, that the overlap among forecasts produced by the three

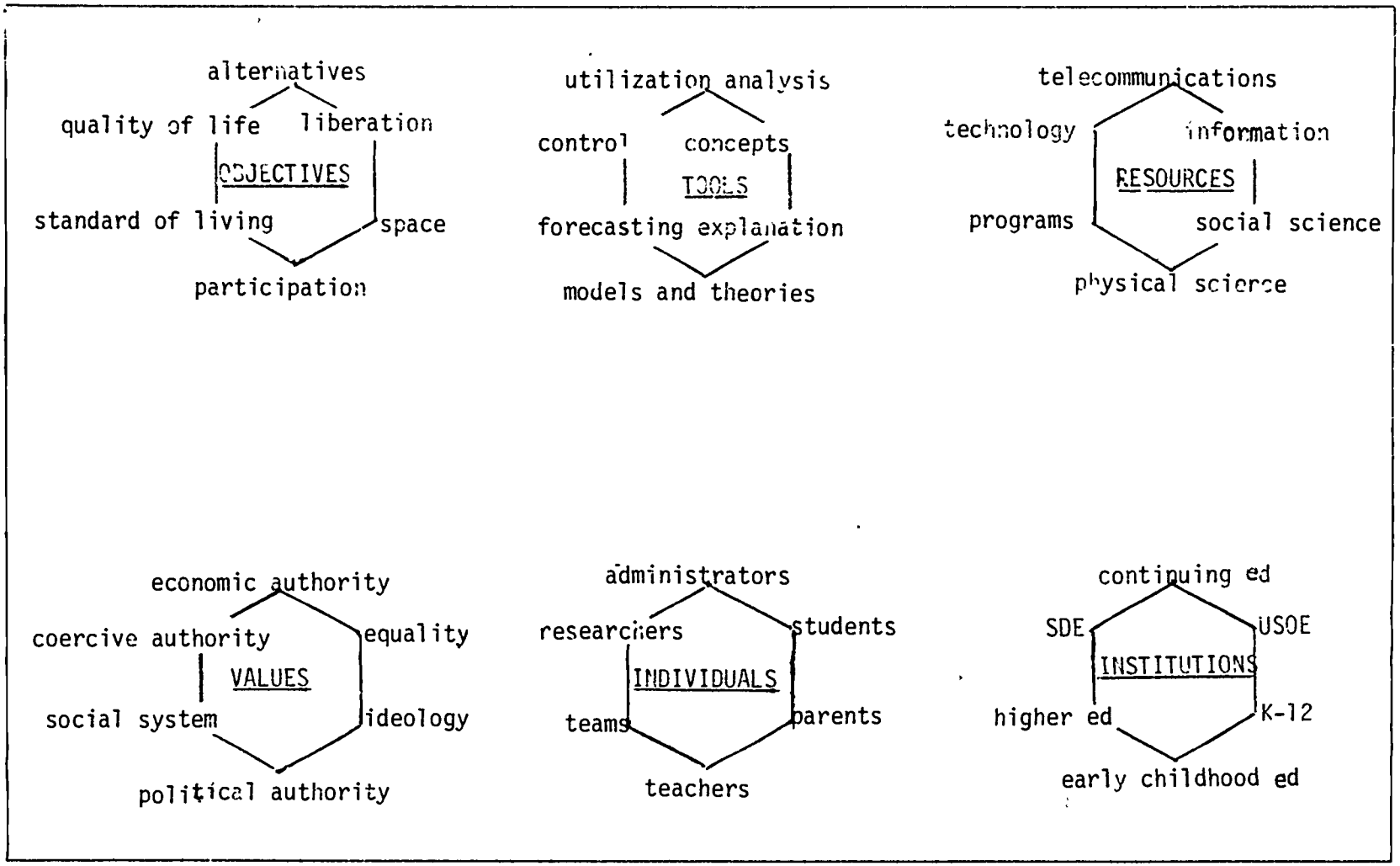

Figure 4. Categories and Subcategories of Possibilities and Constraints

methods, that is, the probability space which is common to all three, constitutes the most likely forecast of the future that is possible, given current knowledge.

Is this forecasting system by its very comprehensiveness too clumsy and too expensive to employ? We think it is not too expensive. It would not be done often, of course, but perhaps on a yearly basis a cycle of forecasting could be undertaken. The results for each year could be plotted against and compared to those of the years before, and a set of trend lines for the future produced.

In conclusion, we must say that to the best of our knowledge, in the attempts to define educational information needs over the next years in the United States, no comparable method for forecasting future conditions has been used. Without such forecasting, the outcome seems likely to be what it has been in the past, which we eluded to at the beginning of this paper. That is, successes in building educational information systems will continue to be few.

REFERENCE

Anderla, Georges. Information in 1985. Paris: Organization for Economic Co-Operation and Development, 1973.