

OPERATIONS RESEARCH IN EDUCATION

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It is not my purpose today to survey the literature of operations research in education. I will not attempt to summarize such very large-scale operations research activities as the educational planning projects conducted primarily in Europe by the Organization for Economic Cooperation and Development, the general purpose of which is to plan for educational growth in a given country in relation to the total economic development of that country. Nor will I discuss the smaller-scale activities, more nearly resembling systems analysis, which are being conducted at a number of educational institutions in this country, the purpose of which is to rationalize the operations and decisions of those institutions or some other operating educational institution. There are among those projects a number of excellent examples of operations research in education, but at this time I would like to keep them in the background.

This afternoon I would like to take quite a parochial stance and discuss with you those operations analysis activities being undertaken and to be undertaken at the U.S. Office of Education. In January of this year the Division of Operations Analysis was established in the National Center for Educational Statistics in the U.S. Office of Education. I'd like to report to you on the "health and welfare" of that Division and on its future. Our broad mission is to develop and maintain a quantitative, analytical model of the educational system in the United States, utilizing the techniques of operations research to aid the educational decision-maker in formulating policies and charting future courses of action.

The words "quantitative" and "analytical" have mathematical connotations and the mathematical model, one of the hallmarks of operations research, is at the heart of our thinking. Such a model will include a representation of the flow of students through the system; will describe the growth and utilization of professional staff at all levels in the system; will take into account the characteristics of curricula; and will consider the administrative organization and financial resources of the system. It will also permit the educational system to be related to the total United States economic system so that impacts of education on the economy and of the total economy on education can be evaluated.

Much as we would like to do so, we are not in a good position to begin by formulating the model. We must grapple with more fundamental matters, and first among these is developing an operations research capability. In February the staff of the Division of Operations Analysis included three professionals. Now the number of

senior research personnel has doubled and we hope for additional strength and experience in operations research as our group continues to grow. Present members of the staff are concentrating on selecting the relevant variables to describe the elements of the educational system and establishing their parameters and inter-relationships. Then we can proceed to structure the elements and develop mathematical models to represent that structure analytically. These separable activities cannot be carried out completely separately and sequentially and hence we have begun a number of studies which focus on specific segments of the total structure and will culminate in sub-models of it.

The flow of students through the system is one of the segments under study, and Dr. Chandler summarized in her presentation some of the information already available in the Office which bears on this topic. With those data some fairly firm conclusions can be drawn concerning public school enrollment at the elementary and secondary levels. These enrollments have been charted and forecast at the national, and to some degree at State levels. Non-public school enrollments at these levels are less clearly defined, and we are currently trying to improve this complementary segment. Our immediate goal is to describe elementary and secondary student flow in both public and non-public schools by means of sets of curves and functions with their parameters.

Despite all the statistical knowledge we do have, gaps and voids continue to exist, and hence, the immediate goal is just the beginning. As Dr. Chandler also mentioned, we know all too little about what's inside a secondary education; what levels of training the 2 1/3 million high school graduates have had. We know even less, in any integrated fashion, about where those who leave secondary education go. In the immediate future efforts will be directed toward shedding light on these two unknowns. What kinds of students leave secondary school? What segments of the range of intellectual levels do they represent? What socioeconomic levels do they represent? To what kinds of occupations do they go? What other kinds of training do they get and by what means? Where do they ultimately take their place in the social and economic fabric of our Nation? More complete knowledge of the structure of potential our high school graduates possess, and a clearer picture of "dropouts" are already included among the stated requirements of educational decision-makers. The data which Dr. Chandler mentioned exist in other agencies are in general limited in scope either substantively or in area of applicability. We hope to broaden the view and sharpen the picture.

A similar set of educational problems and the research problems related to them can be stated concerning higher education. Their complexity is increased because of the increased diversity in programs of study at the undergraduate and graduate levels. And at these levels the additional dimension of student mobility enters the picture as a significant variable. We need not only to know what kinds of high school graduates enter what kinds of college programs, and how persistent they are; but also, what kinds of institutions enroll those graduates and where they are located. Data are available at several points along the way in higher education on both kinds and numbers of students. Our efforts will be directed toward selecting significant indicators, eliminating gaps in the data, and developing a meaningful structure.

The measurement of level of educational achievement, which comprises another major segment of our efforts, has taken on increased importance in recent months and we are taking steps to broaden our information on this basic indicator of the status and progress of education. Reliable measurement of the level of educational attainment at the national level is not yet available. Technical matters related to comparability of measuring instruments and philosophic differences related to national assessment have thus far militated against such measurement programs.

Dr. Weinfeld has already mentioned that this fall in an Educational Opportunities Survey required by the Civil Rights Act of 1964, some data on educational achievement will be collected, along with other data concerning students' backgrounds and their school and community environments, from a nationwide sample of elementary and secondary students and from a smaller sample of students enrolled in higher education. These data together with earlier data from project TALENT will provide initial material for models that use achievement as a criterion. More broadly representative data may become available in 1967 as an outcome of the research project currently being sponsored by the Carnegie Corporation which Dr. Weinfeld also cited. The cornerstone of this project, the purpose of which is to develop a national assessment of educational achievement, is a group of measuring instruments which are specifically designed for program evaluation and specifically designed to preclude individual evaluation or any indication of a national curriculum.

Educational achievement is not only the indicator of the level to which we have educated but also plays a vital role as a primary criterion in the measurement of quality in education. Similar statements can be made concerning the importance of measurement of educational level in connection with evaluation of program objectives.

How effectively are our curricula meeting our needs? Is content at one level well articulated with content at the next? How effective are our methods in fostering learning on the part of our students? Analysis of achievement data can provide at least partial answers which can be interpreted in the context of other aspects of the educational process.

In advance of the availability of these data, we have begun research in parameter and relationship estimation with variables which we feel with some certainty are relevant to the process of education. Toward that end, one of our current efforts involves some special analyses of data collected on some 400,000 secondary school students who participated in project TALENT in 1960. We plan to use a variety of regression analysis techniques in seeking structure among not only achievement variables, but also student, teacher, school, and community characteristics which are available in the TALENT data. As we progress in this area we plan to use other bodies of data which already exist and also to relate our findings from these efforts to current data. Resource allocation studies and studies of costs of education, which I'll mention again later, may also utilize these results.

You may have noticed that my remarks concerning educational achievement, as were my earlier remarks about student flow, have been heavily weighted toward elementary and secondary education, and measurement of college and university students had only the barest mention. At the lower levels curricula are less complex, measures are in greater variety and abundance and more easily developed where lacking (though some excellent general achievement measures which are well accepted exist in higher education), the volume to be measured is roughly ten-fold that of higher education; and I could go on ... But perhaps the most important reason for our beginning at the elementary and secondary levels is the recently enacted Public Law 89-10: The Elementary and Secondary Education Act, 1965. This Act specifically requires yearly program evaluation by techniques which include measurement of educational achievement. Nonetheless, as we progress and time and staff become available, it seems clear that our work will lead us into measuring achievement in higher education.

From what I have said it is apparent that the results of our efforts have implications for manpower, and we intend this to be so. The product of the educational process is manpower and the studies I have discussed are all bent toward finding out more about that product. As still another major area of endeavor, separate efforts must also be undertaken to relate that product to the demands in the total manpower structure. The detailed study of the feedback loop within the educational system from output as graduates to input

as professional staff seems particularly appropriate for the Office of Education. How is level of preparation associated with level of teaching? What are the patterns of faculty mobility, and how do they relate to experience, salaries, personal and social goals, and other factors such as these? Over what ranges is the relationship between level of educational expenditure and quality of instructional staff significant? These are but a few examples of questions concerning which greater insight is needed. Our present work is focused on assessing the data base, bolstering where necessary, integrating within the area, and relating to other areas of data.

As we progress in our analysis of the products of education, we will assure that our work is related to other agencies' manpower research efforts and other sources of manpower data. Questions similar to those I raised concerning "dropouts" can also be asked concerning educational output generally.

The costs of education--in dollars, manpower, facilities, and other resources--represent still another area of investigation to be included as a part of the total model development effort. Estimation of the cost per student of education to specified levels will be developed not only in overall terms but also for broad fields within the total spectrum of education. In other studies the cost of educating various segments of the population to specified levels will be estimated, the value of such educational programs will be assessed, and the "flow of funds" through the educational system will be described.

Projected costs and projected effects must be related in cost-effectiveness studies so that alternative courses of action can be considered and evaluated and decisions concerning allocation of resources made. These studies, to be maximally useful, must take into account economic factors outside of education both of the kind which have an effect on education, and of the kind which are affected by education. For example, a significant decrease in the dropout rate at the secondary level forecasts an immediate "shortage" effect on certain segments of the labor supply, a later effect towards increasing college enrollment, and perhaps a still later "surplus" effect on other segments of the labor supply. The overall model of the educational system under development will enable consideration of such possible effects.

In summary, the analytical models of the educational system that are being developed will encompass quantitative relationships describing flow of students through the system and into the labor force, flow of faculty and staff into and out of the system, allocation of resources of all kinds to programs conducted by the system, and measures of the costs incurred for and gains derived from those programs. Our goal is to enable the educational decision-makers, through the use of these quantitative models, to evaluate the progress of current programs and to assess, prior to their adoption, proposed courses of action and proposed policy changes in the sphere of education.