Operations research

With The Author's Compliments

Concerning instruction in operations research and management science:

Text of a presentation delivered in Panel on Education, conducted at joint meeting of Operations Research Society of America and The Institute of Management Sciences, March 30-31, 1956, Los Angeles, California.

Edward W. Barankin

Concerning instruction in operations research and ... n, p. ... 1956.

CONCERNING INSTRUCTION IN OPERATIONS RESEARCH AND MANAGEMENT SCIENCE

Edward W. Barankin

There are two views to be taken on the problem of designing education in Management Science and Operations Research: the view in terms of immediate needs, and the long-term view. My remarks are addressed to the long-term view. That the prospects for the long-run must be carefully heeded in taking actions of such permanent implications as the formation of university curricula and centers--this hardly need be stressed before this audience.

Obviously, the soundest approach to conceiving what education in a field will be in the long-run, is through an understanding of the nature of the field. In fact, when "long-run" is understood in the full-blooded sense--not simply the next few years--then this is the only approach.

Let us speak, then, about what Management Science and Operations Research are. One of the ear-marks of an O.R. situation is group attack on the problem at hand. In one case there may be a chemical engineer, a marketing expert and a policy-setting official putting their heads together with the O.R. analyst; in another case there will be perhaps physicists, communications engineers and specialized consumers deliberating together with O.R. analysts. One could run through the entire list of well-recognized scientific, industrial and social specialties, and touch every one of them with either actual case histories of O.R. work or indications of organizations that could benefit by Operations Research. What does the O.R. analyst bring to these cooperative situations? To be sure, he

brings mathematics. But this doesn't answer the question. His use of mathematics bespeaks the precision of his work. What is his work? Is it merely that of coordinator, pulling together pertinent facts, different ones of which belong to distinct, absolutely fundamental categories of behavior: physical, chemical, industrial, human, etc.? If this is so, then the O.R. analyst is plainly and simply a jack-of-all-trades. Or is the O.R. analyst's work a single discipline in itself, not composed of lots of individual fundamental disciplines, but itself the most fundamental discipline? I assert that this is the case. And I hasten to add that this conclusion is not a result of a vain intention to glorify the Operations Research analyst; it is a corollary of the results of my own investigations into the nature of probability and behavior.

It is not my plan to enter into the details of my research here. But briefly, the findings are these: that all behavior--be it physical, chemical, industrial, biological, psychological, or of whatever description--is structured of the same kind of primitive elements; namely, eventualities, probabilities and acts. In a word, all behavior is the evolution of stochastic processes. (I use the term "stochastic process" for the real thing, not for the representation on paper of the real thing.) Past thinking has found it necessary to believe that stochastic processes are only one particular category of real phenomena; that there is another, distinct category of "deterministic" phenomena, and still another distinct category of "utility-motivated" phenomena. But in actual fact, deterministic phenomena are a particular type of stochastic process;

and utility is a concept defined in terms of the primitive elements of a stochastic process.

It is by virtue of this unitary structure of reality that we find today, inevitably, the phenomenon of one particular type of scientist--the Operations Research analyst is what we are calling him at the moment--going in among physicists, chemists, engineers, economists, production managers, vice-presidents, etc., who have a mutual purpose, and bringing their individual areas of specialized knowledge of their aggregate situation into a singly comprehended whole. The O.R. analyst is there to bring understanding of the full stochastic process that is in question. The O.R. analyst is an expert on the structure and investigation of stochastic processes. The physicists who are involved in the investigation at hand are men whose particular intuition and knowledge concern characteristics of certain marginal processes of the full process--the marginal processes that we call "physical processes." The production specialists who may be involved are men whose knowledge and insight pertain to over-all characteristics of other marginal processes of the full process--the marginal processes that are called "production processes." And so forth. The O.R. analyst's function is the detailed, precise integration of these several pieces of insight and knowledge into the unified specification of the full stochastic process under concern. This specification will be assumed to incorporate all the pertinent eventualities, but it will embody indefinite parameters; some of these parameters are to be estimated or tested for by sampling, the others thereupon to be fixed by choice. The function of Operations Research extends to the handling

of these problems of estimation and testing, and of optimal choice.

This is what Operations Research is. And having come to this conclusion, we have come as well upon an identification. There is a scientist who goes by another name, whose training is in precisely the three areas of expertness of the Operations Research analyst, (1) the structure of stochastic processes, or--what is the same thing--the mathematical theory of probability, (2) the theory of estimation and testing of hypotheses, and (3) the theory of optimal choice, or, equivalently, decision theory. The man I am referring to is the statistician.

This is the conclusion that is so significant for educational planning: the highly trained O.R. analyst and the highly trained statistician are one and the same thing.

After his training, a statistician may, and usually does, confine his attention to a restricted class of processes. Thus, we have industrial statisticians, medical statisticians, agricultural statisticians, and so on. It is another such concentration, one that we might call "Management Statistics," that is being created today under the banner of Management Science.

The points I wish to make concerning education will now roll forth readily:

(1) It should be realized that the basic theoretical training of an Operations Research analyst is one and the same as that of a statistician. To give the O.R. trainee any less than the full basic training of a statistician is to prepare him for frustration.

(2) If an O.R. trainee is planning a concentration on management processes, his specialized training should come through a series of courses developed and presented with close cooperation between the Departments of Business Administration and Statistics. This is one sure way to achieve and maintain imaginative mathematical treatment of substantive material. The very same holds true for cooperation between the Department of Statistics and Departments of Engineering, or any others which must supply substantive training to prospective O.R. analysts.

The need for this cooperation cannot be urged strongly enough. It is, for example, a serious mistake to think that we are today ready to fashion a curriculum in Management Science which would correspond exactly to a curriculum in, for example, Physics. The big difference is that the precise mathematical structures of many physical processes are fairly well understood today, while in the case of management processes we have just begun to break the ice toward their mathematical comprehension. A physicist can remain occupied for a life-time with the investigation of Newtonian and Schrödinger processes. The management scientist or O.R. analyst, on the other hand, is still encountering multitudes of different types of mathematical structure in the processes he is called on to investigate. It is deplorable failure in our duty as teachers to lead our students to believe

that they can handle management problems when they are prepared with only a small handful of mathematical types of stochastic processes. The only effective way to avoid this is to impart to them a capability of understanding structure and statistical analysis of stochastic processes in a perfectly general way. And this is to be had by the cooperation of a Department of Statistics.

(3) Finally, let us look to ultimately eliminating administrative and organizational confusion, and the resultant confusion in the minds of our students. I am referring to the redundancy in the terms "operations research analyst" and "statistician," and in the terms "management scientist" and "management statistician." Let us not perpetuate the illusion that there are four fields here when in fact there are just the two. Let us not create multiplicities of overlapping curricula, with the inevitable antagonisms between competing instructors, and the inevitable perplexity for the student, who surely always gets the short end of the stick as a consequence of such profusion. The ticket is, again, cooperation. Let the student be sent, for a sound, extensive training in probability and statistical methodology, to the experts in this field, the statisticians; let him be sent, for sound training in the attributes of business processes, management processes, industrial processes, and so forth, to the qualified expert centers, the Departments of

Business Administration, Economics, Engineering, etc. And for his instruction in the combination of these two aspects of his subject matter, the analytic and the synthetic, let neither of the two varieties of experts presume to do it alone. But let them devise some feasible mode of joint instruction, which in itself will be, for the student, an object lesson in the nature of his work.