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PRESIDENTS' SYMPOSIUM: REFLECTIONS ON OR/MS EDUCATION

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This essay compares OR/MS education with educational programs for two other professions—medicine and statistics. It urges an overall review of OR/MS curricula and makes recommendations for changing the profession's education.

McCloskey (1987) has provided an excellent overview of the beginnings of operations research as a field of study. As a result of the success of operations research during World War II and early studies by organizations like The Rand Corporation, a number of pioneers in the profession founded, in the early 1950s, the Institute of Management Sciences and the Operations Research Society of America. Of course, none of the successful practitioners of this era had been formally trained in operations research; they had studied the classical disciplines of physics, chemistry or mathematics.

Since the beginning of OR/MS 40 years ago, professionals have debated the best methods of teaching operations research. Many of the initial programs, as described by McCloskey (1954), were based on a problem-solving approach, such as the one undertaken at Case Institute (later Case Western Reserve University); others were science- or technique-based. Since then, the operations research/management science journals, fueled by increasing criticism that students who are grounded only in applied mathematics cannot solve real OR/MS problems, have published a continuing dialogue about improving operations research education. Some have argued that a practicum should be included in the educational program, while others have claimed that we should teach only science and techniques and leave the practicum to on-the-job training.

Starr (1970) classified OR/MS education as falling into four categories: mathematical operations research; the organization-theory and human-behavior school; the case method and role playing approach; and problem-oriented management science. I would submit that most formal education that goes by the OR label today is mathematical operations research. Ackoff (1970) proposed foundations, fundamentals, frontiers and facilities as the essential parts of an educational program in OR/MS. Most of our present programs do a good job with the foundations and fundamentals, while very few do much with frontiers and facilities. Frontiers are of two types: (1) new areas of application and (2) problems of research methodology that constrain our ability to improve the operations of systems in need of help. By facilities, Ackoff meant a combination of the abilities to use what is known, to find out what others know that is relevant, and to develop knowledge that otherwise would be unavailable and without which the problem could not be solved.

If we look at other fields, it becomes evident that the operations research profession is not unique in searching for better education for its practitioners—the medical profession, for example, has also been struggling with its educational objectives. And in an applied science such as statistics, educators have faced a controversy regarding theory and relevance in undergraduate and graduate programs. Many profession-

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als are also dissatisfied with and lack of confidence in their fields' educational practices. As with operations research, much of the underlying concern is a version of the rigor-or-relevance dilemma, for which Schön (1987) has provided a detailed description. (Schön's work will be discussed in more detail later in this article.)

This article compares and contrasts educational programs for operations research and those of some other professions. It also makes some suggestions for changes in OR education.

Medical Education

Prior to 1910, there were many proprietary medical schools with no accepted standards; in that year, the work of Abraham Flexner started a revolution in U.S. medical education. His report precipitated a significant decrease in the number of medical schools, and stimulated those that remained to restructure their curricula to provide a common core of science for the first two years and clinical training for the last two. During the past 75 years, medical education has continued to evolve. In the 1950s, many programs used an organ-system approach; medical students studied such systems as, for example, the cardiovascular system. Some medical schools in the early 1970s introduced a problem-oriented program wherein the students were given real problems to solve, such as a sore throat, and had to prescribe a treatment. Medical training continues after graduation through internships and residencies, during which new physicians not only learn how to apply the science and techniques they have studied, but also are actively coached by senior practitioners.

Medical career choices have been studied with respect to the influence of medical education. After D. H. Funkenstein (1978) tracked Harvard medical students for a quarter of a century, one of his discoveries was that these students' career choices were related to the general social atmosphere of the time rather than to what happened to them educationally in college or medical school. In fact, the general interests of the students and what they wanted to accomplish has varied from decade to decade, often quite abruptly, since a social era can change very quickly, influencing student career choices from one year to the next.

Funkenstein also showed that students are realists who adapt their career choices to the economic conditions and career opportunities available at any given time. Yet another conclusion was that students' interests *prior* to their entering medical school had greater influence on what they did in the rest of their careers than anything that happened in medical school. Funkenstein's results showed that, based on their aptitudes in science and on quantitative studies as well as on social interests, medical students' career choices could be predicted with reasonable accuracy. By using the Medical College Admission Test (MCAT), college course grades, the Strong Vocational Interests Blank, and certain questionnaires administered at matriculation, Funkenstein placed the students on a continuum from bio-scientific to bio-social, with the basic scientist at one extreme, the psychiatrist at the other. Based on these data, he found it possible to predict the career type an individual will seek. The scientifically oriented students often entered basic research or academia, and when this type of student did practice medicine, he or she used science to help cure patients. By contrast, the bio-social individual tended to work directly with people, using science more pragmatically.

(As an aside: The medical profession has a tradition of lifelong learning which we in the OR community would do well to emulate. Many physicians regularly attend weekly seminars, or take short courses or workshops, to update their knowledge and skills. We OR workers ought to consider expanding our current efforts in continuing education.)

Statistics Education

Though much older than its counterpart in operations research, statistics education has gone through stages similar to OR education. At the turn of the century, there was no formal statistical instruction. Later, the British and Indian schools that developed under K. Pearson, R. A. Fisher, J. Neyman, and P. C. Mahalanobis presented programs that consisted of a mix of theory and practice with senior scientists. In the United States, early statistics programs were given in mathematics departments, schools of agriculture and other areas. A high percentage of these courses offered statistical laboratories along with more formal education. Later, many of our leading universities established departments of statistics, but over the years the amount of practicum in programs has decreased.

Statistical education and statistics itself have received a number of criticisms in the last three decades. I quote from a fundamental paper by J. W. Tukey (1962):

> For a long time I have thought I was a statistician, interested in inferences from the particular to the general. But as

I have watched mathematical statistics evolve, I have had cause to wonder and to doubt.

If I substitute "operations researcher" for "statistician" and "operations research" for "mathematical statistics," I would share Tukey's feelings. He points out that the teaching of data analysis, while never easy, has been made more difficult by the following clichéd, and false, perceptions:

> avoidance of cookbookery and growth of understanding come only by mathematical treatment, with emphasis upon proofs;
>
> it is really quite intolerable for the teacher then to have to reply, 'I don't know';
>
> whatever the fact may be, we must keep things simple so that we can teach students more easily;
>
> even if we do not know how to treat this problem so as to be either good data analysis or good mathematics, we should treat it somehow, because we must teach the student something.

The parallels with OR/MS education are obvious.

The Future of OR/MS Education

If Funkenstein's work in medical education carries over to OR/MS education, we may not be able to influence the career of the student merely by changing the curriculum. If the important variable is the type of student who enters the program, we should be examining just what kinds of students we are now appealing to. Are we attracting those who want to see how mathematics can help analyze problems, or are we attracting those who would approach problems of working directly with people and organizations by using science and mathematics in a pragmatic way? If we are not producing professionals who have the skills to pragmatically solve complex, real-life problems, perhaps one of the reasons is that those students who enter our programs lack such an orientation from the beginning. It would be interesting if ORSA or TIMS, or both, would sponsor a longitudinal study of students' orientations at both the master's and doctoral levels at a few of our universities that have had long-term operations research programs.

Pierskalla (1987), in talking about the profession's evolution, has asked the question "How can OR/MS grow?" He concludes that the profession cannot continue its current paradigm but must reach out to new areas of knowledge and new approaches and integrate them into the curriculum. Pierskalla also states that, if operations research is to grow, our educational programs, research and publications must change. In my opinion, we must first change and experiment with our educational programs; we must develop a new hierarchy, one that does not place pure science at the top and applications at the bottom. Maybe what is needed is a study such as Flexner's, which revolutionized medical education early in this century.

Studying the operations research professionals trained over the last quarter of a century—the individuals with master's degrees or Ph.D.'s in OR—would also prove informative. How high have they risen in management? Are any of them CEOs or important government leaders or administrators? And, of the active members of ORSA and TIMS, how many are in high-level management or have served in upper-level government positions at some time during their careers? While these issues need to be studied, I would hypothesize that very few of our members with OR degrees fit in any of these categories.

Funkenstein's results seem to indicate that, even if we change our educational programs, it is of primary importance to consider the type of students we attract and the students' interests *before* matriculation. If so, we have to change not only our educational programs but peoples' perceptions about the programs and about the whole field of operations research itself.

In my view, we may need to attract a different type of student to operations research master's and Ph.D. programs, but this objective can be accomplished only by a radical change in the present orientation of our faculty. Most operations researchers would agree that Ph.D.'s in OR should be grounded in theoretical and applied mathematics. But since these Ph.D.'s become the individuals who design training programs at the master's and doctoral levels, it is not surprising that the students they have attracted to the profession share their scientific orientation.

Ackoff (1970) and others have proposed that operations research join in partnerships with the business community. In urban centers it certainly would be possible to create a faculty composed of successful practitioners *and* academics and thus construct a very different curriculum. A practicum along the lines of the one developed by Schön and his colleagues in urban planning at MIT is an example of such a partnership.

Schön (1987) has written a very stimulating book about preparing professionals to practice in real-life situations. I quote from Chapter One:

> In the varied topography of professional practice, there is a high, hard ground overlooking a swamp. On the high ground, manageable problems lend themselves to solution

through the application of research-based theory and technique. In the swampy lowland, messy, confusing problems defy technical solution. The irony of this situation is that the problems of the high ground tend to be relatively unimportant to individuals or society at large, however great their technical interest may be, while in the swamp lie the problems of greatest human concern. The practitioner must choose. Shall he remain on the high ground where he can solve relatively unimportant problems according to prevailing standards of rigor, or shall he descend to the swamp of important problems and nonrigorous inquiry?

This dilemma has two sources: first, the prevailing idea of rigorous professional knowledge, based on technical rationality, and second, awareness of indeterminate, swampy zones of practice that lie beyond its canons.

Technical rationality is an epistemology of practice derived from positivist philosophy, built into the very foundations of the modern research university.

(Schön's metaphor has been referred to in a different context in an earlier President's Symposium article—Miser 1987.)

This quotation describes a dilemma we face in OR/MS education. While we are training our students to use mathematical theory and techniques to solve well-formulated problems, we too often ignore the fact that the problems of the real world do not present themselves in such well-formed structures. Indeed, practitioners are confronted with dynamic situations that consist of complex systems of changing problems that interact with each other—situations Ackoff (1979) has also called "messes"—and messes must be treated holistically. Unfortunately, the solutions generated by operations researchers are often part of the problem; to quote Ackoff, real "managers do not solve problems, they solve messes."

Schön has used the term "professional artistry" to refer to the kind of competence that practitioners sometimes display in the uncertain and conflicting situations of practice. Although a detailed description of his provocative dialogue on professional artistry is beyond the scope of this article, a quotation from page 13 may entice the reader to peruse Schön's work.

> Artistry is an exercise of intelligence, a kind of knowing, though different in crucial respects from our standard model of professional knowledge. It is not inherently mysterious; it is rigorous in its own terms; and we can learn a great deal about it—within what limits, we should treat as an open question—by carefully studying the performance of unusually competent performers.
>
> In the terrain of professional practice, applied science and research-based technique occupy a critically important though limited territory, bounded on several sides by artistry. There [is] an art of problem framing, an art of implementation, and an art of improvisation—all necessary to mediate the use in practice of applied science and technique.

Over the years, as technical rationality has gained preeminence in most education programs, much of the training in "professional artistry" has been replaced by exposure to systematic scientific knowledge. A good analyst is said to have common sense and intuition, yet we do not attempt to examine artistry carefully and relate it to technical rationality. If, in the fine arts, most students are successfully coached and learn by doing, should we not, as senior management scientists, try to coach our students and have them learn by practical assignments?

Well over 10 years ago, ORSA published excellent guidelines for the practice of OR (Caywood et al. 1971), and these remain relevant for professional practice, with pragmatic headings such as "beginning," "conducting," "reporting," "reviewing," and "following up" a study. The guidelines state that "the practice of operations research, while carried out in a scientific spirit, is applied science, art, or engineering." I wonder just how many of our master's and doctoral programs expose students to these guidelines, either directly or indirectly, through the use of the modeling process of a real problem.

Churchman (1970) has posed some possible changes in OR/MS education. Not specifically listed in his suggestions was a special commission or individual to take an in-depth look at the professions' educational programs and curricula. Has not the time come to name such a commission or individual to look critically at OR/MS education today and recommend changes?

References

ACKOFF, R. L. 1970. Some Ideas on Education in the Management Sciences. *Mgmt. Sci.* **17,** B2–B4.

ACKOFF, R. L. 1979. The Future of Operational Research Is Past. *J. Opnl. Res. Soc.* **30,** 93–104.

CAYWOOD, T. E., H. M. BERGER, J. H. ENGEL, J. F. MAGEE, H. J. MISER AND R. M. THRALL. 1971. Guidelines for the Practice of Operations Research. *Opns. Res.* **19,** 1123–1148.

CHURCHMAN, C. W. 1970. Operations Research as a Profession. *Mgmt. Sci.* **17,** B37–B53.

FLEXNER, A. 1910. *Medical Education in the United States and Canada,* Carnegie Foundation for the Advancement of Teaching, Bulletin No. 4. Merrymount Press, Boston.

FUNKENSTEIN, D. H. 1978. *Medical Students, Medical Schools, and Society during Five Eras: Factors Af-*

fecting the Career Choices of Physicians, 1958–1976. Ballinger, Cambridge, Mass.

McCLOSKEY, J. F. 1954. Training for Operations Research. *Opns. Res.* **2,** 386–392.

McCLOSKEY, J. F. 1987. The Beginnings of Operations Research: 1934–1941. *Opns. Res.* **35,** 143–152 (Part I); 453–470 (Part II); in press (Part III).

MISER, H. J. 1987. Presidents' Symposium: Science and Professionalism in Operations Research. *Opns. Res.* **35,** 314–319.

PIERSKALLA, W. P. 1987. Presidents' Symposium: Creating Growth in OR/MS. *Opns. Res.* **35,** 153–156.

SCHÖN, D. R. 1987. *Educating the Reflective Practitioner: Toward a New Design for Teaching and Learning in the Professions.* Jossey-Bass, San Francisco.

STARR, M. K. 1970. Some Comments on Graduate Education in the Management Sciences. *Mgmt. Sci.* **17,** B32–B34.

TUKEY, J. W. 1962. The Future of Data Analysis. *Ann. Math. Stat.* **33,** 1–67.