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BOOK REVIEWS

Edited by DAVID I. STEINBERG

The Book Review Section is a regular feature of *COMPUTERS & MATHEMATICS with applications*. Reviews are invited of books which are of particular interest to the Journal's readers. A review should ordinarily not exceed two typed (double spaced) pages, and should be approximately 70–50% descriptive and 30–50% evaluative in nature. Manuscripts of reviews as well as books submitted for review should be sent to: Prof. David I. Steinberg, Dept. of Mathematical Studies, Southern Illinois University, Edwardsville, IL 62026, U.S.A.

Mathematical Modeling. By J. G. ANDREWS and R. R. MCLONE. Butterworth, London. 1976. (*Ed. Note*: This review is reprinted with permission from *Mathematical Reviews*, MR56, No. 1854)

There is increasing recognition amongst applied mathematicians that a basic component of their craft—the conceptualization and casting of real world problems into mathematical form—is as important to recognize, and to educate for, as the skills necessary for deft manipulation of formulae. "*Mathematical Modelling*" has emerged as a term to designate such formulation and interpretation activities.

A recent (August 1977) meeting in St. Louis was titled "The First International Conference on Mathematical Modelling". Somewhat earlier the book under review, "*Mathematical Modelling*", was published. In both cases, one senses a vision of a new discipline on the part of the organizers, but the vision is not sufficiently well defined, nor sufficiently well perceived by the participants for a clear realization of that vision to emerge. The result in both cases is a potpourri of mathematical applications impressive in displaying the gamut of disciplines which have been mathematically invaded. But there is very little in the way of direct consideration of the process of mathematical modelling *per se*. It is as if the idea behind these wide collections is that the reader will induce the principles of mathematical modelling if only subjected to enough examples of its application. Alas, there is no reason to believe that the reader, be he conference attendee or undergraduate mathematics major, will be any more successful in explicitly elucidating principles that the visionaries have themselves failed to formulate.

To be fair, the editors of "*Mathematical Modelling*" have provided about 5 pages worth of discussion on the general features of modelling. They stress that the starting point of applied mathematics is that "some empirical situation presents a 'problem' to which an 'answer' is sought". Then comes a stage of simplification or idealization in which significant features are identified. Next these features must be translated into mathematical entities. Here they comment: "This is generally the most difficult stage and one in which it is impossible to give formal instruction!" I find this statement extreme in pessimism and self defeating. Granted that reduction to mathematical terms will always require human creativity, it does not follow that formal instruction is impossible in, at least, the more mechanical aspects of model construction. Finally they stress that the model must be validated, i.e. its ability to represent the real world aspects of interest must be assessed.

There follows a section of brief comments on each of the chapters of the book. These attempt to link the chapter contents to the general issues of formulation, simplification, validation and interpretation just raised. Unfortunately, as already indicated, this attempt is not sufficient to provide instruction in mathematical modelling as such. The specific reasons are manifold:

Each chapter is written by a different author. There is thus very little uniformity in approach. Moreoever, most of the authors concentrate on the *analysis* of models, i.e. obtaining solutions, with relatively little attention paid to discussion of the *general* issues in their specific guises. Indeed, it is remarkable to what extent the editors' comments on a chapter refer to features not brought out by the individual author himself.

Fortunately, the writing is generally lucid and largely, though not entirely, self contained. Moreover, there is a good coverage of the range of current mathematical applications. Thus as a source of models for illustration, this book may be quite valuable. As a text for an undergraduate course in mathematical modelling (for which it is intended), the book could not stand alone. A successful course would rest on the ability of the instructor to greatly expand on the general issues hinted at in the first chapter. The limited time available would force the selection of a few chapters as the basis for which both the specific, discipline related features and the general modelling related issues would be considered in depth. Also the traditional applied mathematics approach largely underlying the book could well be supplemented by a dose of a more computer oriented, supra-disciplinary, systems theoretic approach which does not shy away from the avowedly methodological issues at stake.

The Weizmann Institute of Science
Rehovot, Israel

BERNARD P. ZEIGLER

Application-Oriented Algebra. By JAMES L. FISHER. IEP, Dun-Donelley, New York 1977.

Discrete Mathematics in Computer Science. By DONALD F. STANAT and DAVID F. MCALLISTER. Prentice Hall, Englewood Cliffs, New Jersey 1977.

The books under review are recent entries into the competition for the "introduction to discrete mathematics" market. Developments in recent years in such areas as computer science, economics, social science, etc. have brought about a new kind of applied mathematics. Called discrete mathematics, it is built upon a melange of formal, nonnumerical, algebraic, finitary, and combinatorial sources. In contradistinction, the traditional continuous mathematics rests upon the derivative calculus. The grandfather of texts of this kind is that by Kemeny and Snell (*Finite Markov Chains*. Van Nostrand, 1960) and it has been joined by a considerable number of others offering greater or lesser audience specialization, higher or lower level, more recent developments, etc.

The books under review fit this description. Fisher's text is intended for junior/seniors with mathematical orientation, Stanat's for freshmen/sophomores in computer science.

Both cover certain obligatory ground such as sets, relations, graphs, automata, languages and groups. But where Fisher teaches theorem proof style and focuses on algebraic applications, Stanat teaches concepts and algorithmic formulation. Fisher discusses interesting applications such as interval orders, critical path analysis and cryptography. Stanat uses program verification to motivate what, for computer science students, are abstractions: symbolic logic, relational algebra, etc., and closes with an introduction to analysis of algorithms.

Both books are well written and illustrated, showing a sensitivity to the student derived from classroom experience. Within the scopes of their intended audiences, they make excellent text books.

Weizmann Institute of Science BERNARD P. ZEIGLER
Rehovot
Israel

The Analysis of Cross-Classifications. By H. T. REYNOLDS. The Free Press, New York, 1977, xiv + 236pp.

This is a clearly written exposition which brings the reader well up to date with most of the methods for analyzing categorical data. This is no mean achievement, for methods include the traditional chi-square, the adaptation of ordinary least squares regression, and the more recent developments of log-linear modeling and weighted least squares estimates.

The first third of the text is devoted to a very thorough and relatively non-technical discussion of traditional analyses of two-way tables. Separate chapters are devoted to measures of association for nominal data and ordinal data. The presentation, along with a discussion of the shortcomings of traditional multivariate techniques when applied to nominal data, sets the stage for the author's presentation of alternative techniques.

The best known of these is log-linear modeling. The unit of analysis is not individual scores but cell distributions, and models are specified by taking the natural logarithm of expected cell frequencies or proportions. The model's fit to the data is tested with the familiar chi-square, which can be used to determine whether adding successive terms significantly increases explained variance.

Although it is possible to specify two-way or higher-order interactions, the heirarchial principle requires that interaction terms be multiplicative and considered only in the context of their lower-order components. Though one can test for significance in log-linear modeling, it is difficult to interpret the results in the same way as regression coefficients. Log-linear models, however, have the essential virtue of converting nominal data into a form that does not violate assumptions needed for the legitimate use of parametric statistics.

The final chapter discusses ways regression can be applied to categorical variables, devoting most attention to the weighted least squares approach (GSK). Rather than predicting scores of individual cases, the GSK approach predicts probabilities, e.g. the probability that a particular combination of characteristics is associated with a Republican vote. The resulting regression coefficients can be interpreted as the probability of change in the dependent variable resulting from a change in the independent category. The approach is flexible enough to allow the researcher to enter whatever single-order or interaction terms into the equation he/she wishes. As in log-linear modeling, one's overall model and its various components can be tested through using chi-square. In the case of weighted least squares, however, the chi-square test seems much like more traditional means of testing the significance of regression coefficients, and a discussion which clarifies the difference is warrented.

In touting the virtues of weighted least squares vis-a-vis log-linear modeling for categorical data, Reynolds has failed to discuss one situation in which the log-linear approach is probably superior—the case of a multinominal dependent variable, e.g. four political parties or three papal candidates.

A very helpful feature of the book is its use of illustrative data, thus effectively lifting the manuscript out of the realm of dry theory and formulae. The one shortcoming of Reynolds' data useage is that he too seldom illustrates his tantalizing discussions of the possible effects of control variables. The data serve him best when he uses them to compare conditional probability estimates with log odds estimates.

This reader would like to see more comparisons. While the book enables one better to understand the relationships of a variety of techniques for analyzing the same type of data, it leaves one with the nagging suspicion that the differences between approaches are rather small. In the case of a saturated model, for example, the results of OLS and WLS are apparently no different. We need a study which applies the diverse methodologies to the same data set, compares the findings of each, and draws conclusions as to their differences. The study would be heavily dependent on Reynolds.

Southern Illinois University JEFFREY W. WIDES
Edwardsville, Illinois, IL 62026, U.S.A.