DOCUMENT RESUME

ED 072 828 LI 004 205

| | |
|---|---|
| AUTHOR | Reilly, K. |
| TITLE | Education in Information Science: The Applied Disciplines in a Systems-Oriented Curriculum. |
| INSTITUTION | California Univ., Los Angeles. Inst. of Library Research. |
| SPONS AGENCY | National Library of Medicine (DHEW), Bethesda, Md. |
| PUB DATE | 30 Jun 70 |
| NOTE | 29p.;(22 References); Number 4 of a Series of Reports on Education for Information Science (Documentation) |
| EDRS PRICE | MF-$0.65 HC-$3.29 |
| DESCRIPTORS | College Curriculum; Computers; *Course Descriptions; *Information Science; *Library Education; Library Schools; Operations Research; Statistics; Systems Analysis |
| IDENTIFIERS | *Information Science Education; UCLA; University of California (Los Angeles) |

ABSTRACT

This report is the fourth of a series of reports on Education in Information Science (Documentation). The first three reports cover educational issues in general and the details of central course offerings in the UCLA Library School program. These reports are reviewed and commented upon to set the stage for the present writing which outlines the kind of courses that are needed to meet the requirements for "applied disciplines" in a systems-oriented curriculum. Three course descriptions are presented, one in each of the areas of systems analysis, statistics, and operations research. These courses emphasize the computer, not simply as a computational aid but also as a means for conceptualization of the system in the systems analysis course, for gaining insight into statistical theory in the statistics course, and for system simulation in the operations research course. Some of the difficulties the student faces in putting together a sequence of courses of this type are discussed and the possibility that the library school itself might offer such courses is investigated. (Other reports in the series are ED 039 911, 041 484, and LI 001 977.) (Author)

# EDUCATION IN INFORMATION SCIENCE:

# THE APPLIED DISCIPLINES IN A SYSTEMS-ORIENTED CURRICULUM

K. Reilly

Number 4 of a Series of Reports on

Education for Information Science

(Documentation)

NLM Grant 119

June 30, 1970

Institute of Library Research
University of California
Los Angeles, California

ABSTRACT

This report is the fourth of a series of reports on Education in Information Science (Documentation). The first three reports cover educational issues in general and the details of central course offerings in the UCLA Library School program. These reports are reviewed and commented upon to set the stage for the present writing which outlines the kind of courses that are needed to meet the requirements for "applied disciplines" in a systems-oriented curriculum. Three course descriptions are presented, one in each of the areas of systems analysis, statistics, and operations research. These courses emphasize the computer, not simply as a computational aid but also as a means for conceptualization of the system in the systems analysis course, for gaining insight into statistical theory in the statistics course, and for system simulation in the operations research course. Some of the difficulties the student faces in putting together a sequence of courses of this type are discussed and the possibility that the Library School itself might offer such courses is investigated.

## INTRODUCTION

The Institute of Library Research and the School of Library Service at UCLA have worked together in the initiation and integration of Information Science courses into modern library school curricula. The effect of the computer on libraries has led the School of Library Service to expand its curriculum to include the study of computerized techniques. The Institute of Library Research, on the other hand, with its commitment to research, is looking ahead to the long range relationships between librarianship and other disciplines, such as computer science, business administration, and linguistics. The series of reports, of which this is the fourth, has tried to show the importance of these relationships. Another report, on a "Study of the Needs for Research in Library and Information Science Education", headed by Professor Borko of the School, has emphasized the need for this kind of combination of education and research. Together, these projects provide a basis for evaluation of the directions that are being, or are about to be, taken.

## REVIEW OF PREVIOUS REPORTS IN THE SERIES

In order to set the proper context for this report, let us review the contents of the prior reports in this series. The first (Hayes [1]) provides a broad overview of the structure and content of the information science program offered at UCLA. This program is an inter-disciplinary one, though it is headquartered within the School of Library Service. The major emphasis of the program is placed on "information system design", one of the several principal approaches that have been identified

in the teaching of information science. The course work of the program can be divided into four sections; a listing of some of the individual courses (or course areas) is given below with the appropriate heading:

Area 1. System Design and Integration:
- Statistics
- Operations Research
- Techniques of Mathematical Modeling

Area 2. Organization of Information Records:
- Cataloging and Classification
- Comprehensive Bibliography
- Specialized Bibliography

Area 3. Management of Information Activities:
- Managerial Accounting
- Specialized Library or Information Centers
- Management of Libraries

Area 4. Use of Equipment:
- Computer Programming
- Computer Applications

A background of courses such as these provides the student with a common core of knowledge upon which he can specialize, usually within one of the latter three areas listed above. A thesis is required and generally involves a problem interrelating these three areas and using the tools of the first area.

The second report in the series attempts to account for the diversity of programs found under the rubric "information science" by resorting to a broad definition of information:

> "Information is the data produced as a result of a process upon data. That process may simply be one of data transmission (in which case, the definition and measure used in communication theory are applicable); it may be one of data selection; it may be one of data organization; it may be one of data analysis."

This definition and its subsequent characterization serve to show clearly the presence of distinct components of information science. Data transmission is largely an engineering concern and the theory on it, known as Information Theory, is a complex mathematical development in its own right. Curricula based upon this approach tend to emphasize mathematics, logic, language, and computer software.

In order to focus upon the other information science components we must first recognize that data selection, organization, and analysis have been of perennial interest to many disciplines (e.g., library science, business administration, sociology, etc.) but when the new technological element, the computing machine, is introduced, the emphasis generally changes. This change in emphasis has led to development of systems oriented curricula which emphasize the methodology of systems analysis in one or more institutional contexts (such as a library, a business, a governmental organization, etc.).

When the interest in the computer element becomes so total that data selection, organization, and analysis are thought of almost exclusively in terms of computer hardware and software systems, a third emphasis emerges, the computer science-oriented curriculum, which emphasizes computer data organization, computer algorithms for selecting data, statistical processing, and mathematical model building for analysis of data.

The fourth curriculum is specifically library-oriented. Due in part to the fact that librarianship is more totally involved with information processing than any of the other areas that we have mentioned, many

library schools have felt the need to change their names to School of Librarianship and Information Science, automation of technical processes in libraries and the recognized potential for information retrieval services in libraries leading them to include courses about computers in their curricula. These programs tend to treat information science as simply the use of computers in support of present day operations in libraries and information centers, including mechanized information retrieval.

After having made these distinctions, Hayes then lists the course work each of these points-of-view imply; divided into formal and applied disciplines, computer-oriented, management-oriented and service-oriented courses on one axis and theory-, computer science-, systems- or library-orientation on the other, the corpus of studies appears as in the matrix of Table I. The legend for this diagram requires that "1" signifies a required course, "2", a recommended course, and "3', an elective; "pre-req", a prerequisite. We see clearly from this diagram where the emphasis of each approach lies. It is helpful for our purposes to concentrate on the levels of highest priority within the systems-oriented curriculum. The present report is directed to discussion of the required courses in the Applied Disciplines: statistics, operations research, and systems analysis.

The third report in this series (H. Borko and R. Hayes (3)) discusses the systems-oriented curriculum in more detail, with particular comments on courses being taught at the present time in the Library School at UCLA. Here, perhaps more clearly than elsewhere we are given

TABLE I

| Representative Courses | CURRICULA | | | |
|---|---|---|---|---|
| | Theory Oriented | Computer Oriented | Systems Oriented | Library Oriented |
| <u>Formal Disciplines</u> | | | | |
| Calculus | Pre-req. | Pre-req. | Pre-req. | -- |
| Programming | Pre-req. | Pre-req. | 1 | 2 |
| Symbolic Logic | 1 | 1 | 3 | -- |
| Recursive Functions | 1 | 1 | 3 | -- |
| Linguistics | 1 | 2 | 2 | -- |
| <u>Applied Disciplines</u> | | | | |
| Statistics | 3 | 3 | 1 | -- |
| Operations Research | 3 | 3 | 1 | 3 |
| Psychology | 2 | 3 | -- | -- |
| Information Theory | 1 | 1 | 3 | -- |
| Systems Analysis | -- | 3 | 1 | 2 |
| Methods of Social Research | -- | -- | 2 | -- |
| <u>Computer Oriented Courses</u> | | | | |
| Computer Hardware | 3 | 1 | 2 | 3 |
| Compiler Construction | 3 | 1 | -- | -- |
| Data Base Management | 3 | 1 | 1 | 2 |
| Information Retrieval System | 1 | 1 | 1 | 1 |
| Management Information System | -- | 3 | 2 | -- |
| <u>Management Oriented Courses</u> | | | | |
| Managerial Accounting | -- | -- | 1 | 3 |
| Organization Theory | 3 | -- | 2 | -- |
| Information Center Management | -- | -- | 1 | 1 |
| <u>Service Oriented Courses</u> | | | | |
| Sources of Information | -- | -- | 2 | 1 |
| Catal., Class., Index., Abst. | 2 | 2 | 2 | 1 |
| Documentation | -- | -- | 2 | 1 |

a view of the particular slant that this program represents: "The emphasis is on the management and decision-making aspects of information systems rather than on the operational and service needs." This quotation helps in understanding the rationale for the "required", "recommended" and "elective" status for the courses outlined above.

The Borko and Hayes report describes five specific courses in detail:

1) Introduction to Information Science
2) Data Processing in the Library
3) Information Retrieval Systems
4) Information Systems Analysis and Design
5) Seminar in Information Science

Accompanying the course descriptions is a discussion of the sequence in which they and some of the other courses in the program are taken (over approximately a 1 1/2 to 2 year period). Most of the course work is taken in the first year with the second year dedicated mainly to research and to the thesis.

The Seminar (item no. 5 above) is the planned point of departure for the thesis work. In this course each student is required to develop a thesis proposal, usually in one of the major areas recognized by the Annual Review of Information Science and Technology (4):

Information needs and uses
Man-Machine communication
Information system evaluation
File organization and search techniques
New hardware developments
Content analysis, specification and control
Automated language processing
Information centers
Information networks

"research on scientific documentation and information retrieval". Some of the particular topics of this course overlap, of course, with those of other courses and hence all the material of this book (as well as that of Lancaster's book) is not covered totally in this one course. Lancaster's volume is a much slimmer affair than Kent's but equally weighty in its offerings. Fresh from his experience in evaluating the MEDLARS project, Lancaster is well equipped to aim at providing a view of the considerations that are paramount in the mind of one charged with "testing and evaluation" of information retrieval systems. Lancaster achieves his goal through careful development of background on indexing, searching, "completely mechanized information systems", etc., to set the stage for description of a test program, test data, analysis, and attribution of system failures to one of the categories: 1) due to the index language, 2) due to the indexing operations, 3) due to the searching process, 4) due to user-system interaction difficulties, and 5) due to other causes (e.g., computer breakdown, clerical error, etc). Remaining chapters in Lancaster discuss improvements in information retrieval systems through the various channels (especially indexing and search strategy) and some remarks on economical factors of an information retrieval system.

The fourth course, Information System Analysis and Design, consists of three main portions, the first of which treats systems analysis and design primarily from the management point of view. Although not specifically assigned as a textbook for the course, this portion is perhaps most similar to the first half of the book edited

by Rosove (9). The second part of the course deals with critical problems in actual implementation of a system on the computer: file organization and associated search strategy. Again, no specific texts are assigned to this portion of the course although much of Lefkovitz (10) and the chapters of the Annual Review of Information Science and Technology form the basis for the discussion. In the latest version of this course (Spring, 1970) students were able to get "hands-on" experience with use of the computer in search of various file organizations using the ERIC (Educational Resources Information Center) data base. The final portion of this course treats "The Use of Theoretical Models" using the assigned text, Morse's Library Effectiveness: A System's Approach. It is important to realize that the student will study from this book rather late in his career, after he has had or while he is having general training in systems analysis, statistics, and operations research, so that this material can be treated pretty much on an applications basis.

## AN APPLIED DISCIPLINE SERIES

The above discussion summarized the previous reports of this series. The purpose of the present report is to present another group of courses in the training program. These courses are taken concurrently with those discussed above and cover systems analysis, statistics, and operations research. Effecting a satisfactory sub-program in these areas within any of the Information Science approaches has been difficult. The theory- and computer-oriented approaches have become so preoccupied with either "formal disciplines" or

"Computer-oriented courses" that they have not been able to concentrate much attention on these areas (though some Computer Science programs when joined with Information Science, e.g., in a Computer and Information Science program, are making an attempt to treat these areas properly). Library-oriented students usually do not have an adequate background for entry into these courses. There usually is no set of courses that the students can follow in sequence; courses with the same name taught by different departments vary greatly in content and emphasis. Thus, students with different backgrounds tend to take courses at different levels and accordingly it is difficult to create the kind of climate that education is naturally supposed to create: i.e., one in which its products, the students, can communicate among themselves and thus advance the general level of their subject. To some extent, these problems could be remedied by providing a sequence of courses within the library school, perhaps similar to that to be discussed below. However, the Library School at UCLA has not added such courses at this time since it is debateable whether they should be offered by a library school at all, for they are not high priority courses in library-oriented programs. As a result, the courses in the sequence are taught in other departments and thus not on the best basis for students of Information Science pursuing degrees from the Library School.

This report will describe three courses, two of which the present writer has taught. Though these courses have been taught for departments other than Library and Information Science, some

library school students have taken the courses and some library-oriented material has been used as examples. These courses can be put into a sequence and our discourse will suggest that sequence.

It is difficult to determine the coverage of any particular department's offerings und' ... eneral topics of systems analysis, statistics and operations research. Those familiar with these topics know that each of these terms, with the possible exception of statistics, are no better defined than is Information Science. Of course, much of the material that is covered in systems analysis and in operations research is standard: flowcharting and block diagramming, certain kinds of statistic and probabilitistic techniques, methods of mathematical modeling, computer simulation, among others. Van Court Hare Jr. in his systems analysis text (12), subtitled, "A Diagnostic Approach", is very much in the mainstream of systems analysis as it relates to complex systems, with chapters on "logic and probability" and "systems simulation". McMillan and Gonsalez, whose text on systems analysis (13) is subtitled "A Computer Approach to Decision Models", place considerably more emphasis on quantitative methods, incorporate many topics found also under operations research. Engineering systems analysis, on the other hand, generally deals with analysis of certain classes of (generally) hardware systems, and incorporates even more mathematical technique. A new course to be offered later this year under the UCLA Engineering Extension program deals with "control and filtering theory and mathematical optimization techniques", the assigned text being on non-linear programming.

The situation is no more clear in the case of OR, as the remarks above about the book by McMillan and Gonsalez may have indicated. However, with the major exception of simulation, which appears under both operations research and systems analysis, OR is generally more quantitative (or mathematical, if you prefer) than mainstream systems analysis. OR generally deals with smaller scale problems than systems analysis, it often being possible to obtain closed-form mathematical, analytic solutions to the systems models.

Statistics is the most clearly defined of the three subjects with a more universally recognized range of topics than in the case of either OR or SA. Statistics as taught to biologists, engineering students, business administration students, etc. (especially at the introductory and even frequently at the intermediate levels) is often composed of nearly the same set of topics. On the other hand, these courses will differ significantly in the level of sophistication required and in the illustrations used.

Despite the potential confusion of these areas, a progression of courses suitable for students in the Information Science program seems possible. The particular set of courses described below is designed to operate within the context of a masters level curriculum and cannot cover the three areas in their entirety. The sequence does provide a view of each area and, because of some now established innovations, gives the student a somewhat more comprehensive view than has been possible in the past. It also represents a graded sequence which brings the student from the relatively elementary to a more complex level of scientific thinking. The sequence may possibly

be stronger in its computer emphasis and weaker in an analytic mathematical sense than other comparable programs. In terms of supporting the systems-oriented curriculum of the Library School, this is quite useful, it being assumed that the computer-related work by the students, described by the other reports in this series, together with these courses will aid the student in more competent use of computers. Analytic mathematics is an area more foreign to the central theme of the curriculum at least at the masters level. This does not mean that the theoretical foundations of these subjects are neglected; for, as we shall see, the computer is not looked upon merely as a device for analysis of data but as a means for gaining insight into theory. At this point we are ready to begin our discussion of the individual courses.

## A SYSTEMS ANALYSIS COURSE

The first course that we shall describe is that of systems analysis. Because of its position in the sequence this course is the most elementary one, at least in terms of the level of quantitative and/or mathematical background required of the students. But there are more fundamental reasons for having this course first, if we accept the statement by Hare (12):

> "The scientific method of inquiry, which demands . . . relevant and dependable relationships for its results, is systems analysis in its broadest sense."

The emphasis on the basics that this implies is just what is needed for students in the IS program, many of whom have had some contact with the scientific method but still need an integrated discussion

geared to the kinds of problems that they will most likely face in their lifetime: complex systems of interrelated components. The course then helps to focus the student's attention on the "total system" and to keep in perspective the parts as they relate to the whole as he proceeds through the progressively more detailed sub-system analysis work in the later courses of the sequence.

Hare is quick, as we are here, to limit the scope of systems analysis to something less than the scientific method (otherwise, he would be perhaps fundamentally obliged to have written a philosophical text rather than one oriented to problem solving). This scope limitation can be achieved (as it was in the paper by R. M. Hayes (14)) by characterizing systems analysis in terms of a multi-stage interactive (or circular) process:

1. Problem Definition
2. Selection of Objectives
3. Analysis
4. Definition of Alternative Solutions
5. Evaluation
6. Iteration and Reiteration

The iteration and reiteration stage is key to the circular process espoused in systems analysis, i.e., the system definition may start out primitively but become increasingly more refined as the systems analysis work continues.

The attention accorded to each of the six stages depends in large measure on the fact that this is the first course in a three-course sequence including statistics and operations research. Accordingly, the stage must be set properly for these later courses but, more importantly, the course's attention need not wander off into either

of these areas (as is so often the tendency in systems analysis courses). The course's computer material must integrate with computer approaches taken in other courses in the IS program, such as those on Data Processing in Libraries and Data Base Systems.

A textbook that achieves most of the goals we have set is that of Hare (12) already referred to above; this book can be recommended for this course. Students in the Information Science program at UCLA can take a course in which this book is the principal text (Business Administration 225 A); the description for this course reads as follows:

> Design of information systems. Emphasizes systems concepts, user's requirements, methods of systems analysis and measurement, coding and classification of data. Use of computerized systems. Utility of information systems relative to the needs of particular organizational decision and control centers.

Its prerequisites are a basic computer course in FORTRAN or some other programming language and some knowledge of accounting systems; it is part of a program for information systems and accounting in the Business School. Though the emphasis is on business applications, the course's systems emphasis renders it the most suitable course of its kind on the UCLA campus.

We shall now describe a somewhat idealized version of this course, one which utilizes the basic text, conveys the systems emphasis, and ties in with the remaining courses in this sequence. The first part of the course is dedicated to problem definition. This area is perhaps one of the most difficult of all to treat within a scientific context, because so many problems that humans face arise from their expectations

and desires rather than from more measurable events and situations. The use of the tools and techniques of flow charts and block diagrams in the definition of the system help to make problem definition more precise and concise. These tools then are described early in the course. The incorporation of the system description into an hierarchical structure comparable to that of higher level programming language (e.g., COBOL and PL/1), as Hare does, is the next logical step in system definition. (This phase of the course is also of value in relation to the other courses since it provides the student with the logical tools of data description). System definition as an aid in understanding the system is not identical to full identification of the problems, because the subsequent stages of the systems analysis process can give rise to new problems.

Having learned how to define the system in a variety of ways, the student is prepared for the stage involving selection of objections, since identification of problems even at the most primitive level leads naturally to selection of objectives for further analysis. Selection of objectives also contributes to narrowing the purview of the system, and the student must be taught some of the techniques of "systems simplification" in order to achieve this end. Student exercises on simplification of the system description, arising from class discussion and homework exercises, lead from virtually unmanageable system definition (at least at the practical level) to a manageable but nevertheless data-rich description. The student is thus taught to remove himself from the simple one-cause/one-effect mode of thinking into a multi-dimensional framework.

In the third phase in the process of systems analysis, the student is called upon to make a detailed analysis of problems so as to set the stage for definition of alternative solutions. Some of the elements of "searching" (both in the sense of searching computer files and in the more conventional sense) are required at this point and the principles of it are taught to the students. This detailed level of analysis may also involve the construction of a model for the system. If the system definition has been reduced dramatically in scope, or if attention can be directed toward a reasonably small sub-system within it, some of the tools of mathematical model building are appropriate and a brief survey of some of these is provided. On the other hand if the system definition remains sufficiently complex, as it does more often than not, the tool called for is simulation; it too is surveyed in terms of its objectives and basic approaches. This portion of the course ties in directly with the operations research course in the series.

The next stage of the systems analysis process is that of definition of alternative solutions. The discussion of this portion of the course is as appropriate to further development of a model of a system as it is to further development of the system description.

For each alternative that is deemed worthy of further analysis an evaluation or test is required. Test procedures themselves are to some extent data productive, and both non-statistical and statistical tools for data reduction and analysis are required. The objectives and principal approaches of statistics are pointed out in this connection,

providing additionally the motivation for the statistics course that follows this course in the series. In order to avoid the possibility that the student will put too much stock in quantitative evaluation measures, he is encouraged to turn his attention to those aspects of the evaluation process that cannot be easily quantified.

Iteration and reiteration is not the same as the previous stages since it involves returning to one of the above stages and once again following through its subsequent procedures. The idea of iteration is still more pervasive than just this, since it makes its presence known at each stage of the system analysis process. Thus, successively more detailed descriptions of the system, starting with a gross level flow diagram and proceeding to the detailed definition of a sub-component in the total system is also an iterative procedure. The discussion of iteration at the end of the course helps to tie together many principal points of the course and thus is a fitting termination point.

## A STATISTICS COURSE

Statistics is somewhat more definable than the other courses in this sequence, as we have already pointed out. However, there are nevertheless different approaches to the subject. Emphasis can be put on "cookbook" procedures, learned apart from further contact with the subject; on the other hand, emphasis can be given to the theoretical aspects of the subject. The ideal course achieves a balance.

Students coming out of a systems analysis course such as that just described are generally well prepared for a statistics course and will have some advantages over the typical student of statistics (who all

too frequently takes a statistical course only because he must and never really learns to appreciate the subject). The edge that the systems analysis-trained student has when coming into the course allows the possibility of incorporating a couple of innovations into the standard applied statistics curriculum. The first of these is utilization of packaged programs for statistical data analysis, as witnessed, for example, by the strong orientation toward use of the computer in beginning statistics courses at the First Conference on Computers in the Undergraduate Curricula (1970) sponsored by NSF. A textbook reflecting this emphasis is already available (15), and many of the newer statistical texts have some computer routines or flow diagrams in them.

A second area is receiving much impetus, but as far as this writer knows has reached book form only in the excellent text by Lohnes and Cooley (16). In it, the computer is used to perform Monte Carlo experiments so as to develop a feeling on the part of the student for the theoretical basis of statistics. The point is that the student who previously applied statistical cookbook procedures in a rote fashion now can absorb many of the insights that theory has to offer and thus should not only grow in appreciation of the subject but in the direction of increasingly sophisticated use of statistics. The Monte Carlo method, since it rests so squarely on sampling from distributions, also helps to integrate central topics of probability with statistics so that a course based in part on use of it contains a good dose of probability. This helps in tieing this course to the following one on operations research wherein probability concepts are repeatedly called upon.

A statistics course of this nature has been taught by the writer within the School of Business Administration. It begins with frequency and probability distributions, as has been the practice in most introductions to statistics. No sooner is the concept of probability distribution developed, though, than it is put to work in simulated sampling. By using "canned" frequency distribution programs and certain process generators the student is led first from simple recovery of a given distribution by simulated sampling to statistical arguments on the sampling distribution of the mean and "goodness of fit" tests. By developing samples of different sizes the student is able to "see" (in plotted and listed form) the tendency of the distribution of sample means to attain an approximate normal distribution as the sample size increases, and thus gain empirical confirmation for the principal assertion associated with the Central Limit Theorem.

Though many of the computer exercises can be handled through packaged programs, the student is encouraged to draw flow charts and under advisement of the instructor turn them into computer programs. A first step for the student is to compute in a Monte Carlo fashion some probability value that he can calculate by hand (e.g., the probability of drawing a given card from a deck of cards and completing an inside straight in a one-person game of poker); a second step is to devise the flow chart (and less likely program because of time limitations) for a calculation that would otherwise be extremely difficult to do by hand (e.g., the step-by-step development of a game of poker with four players, jokers wild, or whatever conditions he wishes to impose). The student cannot be expected to fully comprehend

the far-reaching impact of these studies with familiar games but it becomes very apparent in the next course in the sequence, wherein simulation models for complex "real life" systems are developed.

The next portion of the course proceeds through the topics of correlation and regression and because of the use of the computer some of the multivariate ramifications of these topics can be introduced. The Monte Carlo approach to the theory is called into play in developing the sampling distribution of the correlation coefficient, thus providing insights into the standard tests for sample correlation coefficients. The final portion of the course deals with some of the introductory materials in the analysis of variance, up to and including factorial designs (time permitting).

The students are asked to take at least one mid-term examination and a final besides writing a paper. The paper allows the student maximum leeway, although suggestions are made to develop some kind of simple simulation exercise in an area that is of most concern to them. The principal requirement on the students, beyond looking at a problem of concern to them, is that they make use, to the maximum extent, of the statistical knowledge they have gained in the course work and collateral readings. Materials for the course include the volume by Lohnes and Cooley (16), a statistical handbook or manual such as that by Crow, Davis and Maxfield (17), a manual for a statistical package such as the BIOMEDS, SSP, (Scientific Subroutine Package), or SPSS (Statistical Package for the Social Sciences).

Courses that are already on the books at UCLA and that cover many of these topics are to be found in virtually any department. The students in the UCLA Information Science program are perhaps most likely to choose either a course from Business Administration or one from Education. A half-course involving a computing laboratory is offered in course #213 by the Biomathematics Department.

AN OPERATIONS RESEARCH COURSE

The third course in the Applied Disciplines area of the IS curriculum is one on operations research. The emphasis of this course falls in two main areas: digital simulation and optimization techniques. The course can be divided about evenly on these two principal topics with some of the other areas (e.g., PERT and systems cost-effectiveness) being viewed from these perspectives.

In order to maintain continuity (within the idealized curriculum we have been describing), this course should begin with a discussion of simulation. The students have much of the statistical background for the area of simulation known as discrete-event simulation and thus can concentrate on the model building process itself. In order to achieve maximum benefits of simulation software, the students could learn the main features of a special-purpose language such as GPSS (General Purpose Simulation System), SIMSCRIPT, or GASP. These user-oriented programming languages are in general much easier to learn than general-purpose languages such as FORTRAN or PL/1; the ease with which one can program fairly complex systems models more than makes up for any lost time in learning such languages. Using one of these languages,

the student can study the properties of some of the mainline OR systems, e.g., inventory (or storage), queuing, renewal (or replacement) systems. PERT network analysis also can be utilized as an example, as it is in a number of the texts (Pritsker and Kiviat [18], Schriber [19]). Certain elements of cost/effectiveness can be brought into this context also, perhaps along the lines suggested by Seiler (21). The student should also be exposed to "system postulation" simulation, i.e., simulation involving hypotheses on how a given system, which is only partially understood, might work.

The second area of concentration in the course is that of optimization techniques. The emphasis here is more on numerical methods than on mathematical analysis. Here, the students are introduced to linear and non-linear programming. In the case of the former topic, the emphasis is placed primarily on the SIMPLEX method and applications can be made to network flow (including that of library materials). In the latter area the emphasis is on the special case, quadratic optimization, as this is a far more maniable problem than the general case. The Dynamic Programming approach to optimization for both linear and non-linear problems is briefly sketched.

The writer of this report has taught a course similar to the one just described. The course was taught for the Computer Science department at UCLA and is open to students in the IS program. Statistics is not formally listed as a prerequisite to the course, although virtually all of the students have had some contact with it; only a brief review of statistics is necessary in the course. The description for this course (Computer Science 126A) reads as follows:

Model formulation and programming for discrete-event systems in simulation languages (e.g., GPSS, SIMSCRIPT). The simulation data base and considerations for language development. Statistical considerations: design of experiments, random number generation, analysis of model results. Computer exercises.

The principal text for the course is that by Gordon (21) with the text by Pritsker and Kiviat (18) being highly recommended. The course may use the book by Schriber (19) with that of Pritsker and Kiviat in the future. Optimization techniques have been discussed only cursorily in the course up to the present time. If that portion is treated more fully in the future added support for it may come from the book by Kunzi, Tzschach, and Zehnder (22). This is a numerically oriented work and contains programs in both FORTRAN and ALGOL for the techniques it describes; it presents some of the theory behind the methods at a level that is understandable for students with the background presumed for this course.

## SUMMARY

This report has outlined a set of three courses based for the most part on existing courses within the university but gathered together here as a three-course sequence within an Information Science program. The sequence begins with systems analysis, which is only partially quantitative in outlook, and proceeds in the direction of increased quantitative and mathematical emphasis, ending with a few sketches of mathematical theory in optimization. Each one of the courses has a computer component; many "faces" of the computer are presented: data description and organization for systems definition, Monte Carlo methods for bolstering theoretical knowledge in statistics,

the almost "artificial intelligence" act of systems postulation, calculation methods in statistics and for optimization problems. Mathematical methods, while not shunned by any means, are not the center for concentration in these masters level courses, with the possible exception of the last half of the third course where some theoretical work in optimization is discussed. The student is encouraged throughout to do independent work and should emerge from these courses with a reasonably good knowledge of what these methodologies have to offer and with the preparation to go on to more advanced and specialized courses as he pursues further education either full-time on the way to a doctorate or part-time as a student in continuing education programs.

## REFERENCES


1. Hayes, R. M. EDUCATION OF MEDICAL LIBRARY SYSTEMS ANALYSTS: NUMBER 1 OF A SERIES OF REPORTS ON EDUCATION FOR INFORMATION SCIENCE (DOCUMENTATION). Los Angeles, California: University of California Institute of Library Research. April 1, 1968.

2. Hayes, R. M. EDUCATION IN INFORMATION SCIENCE: NUMBER 2 OF A SERIES OF REPORTS ON EDUCATION FOR INFORMATION SCIENCE (DOCUMENTATION) Los Angeles, California: University of California Institute of Library Research. February 27, 1969.

3. Borko, H. and R. M. Hayes. EDUCATION FOR INFORMATION SCIENCE (DOCUMENTATION): NUMBER 3 OF A SERIES OF REPORTS ON EDUCATION FOR INFORMATION SCIENCE (DOCUMENTATION). Los Angeles, California: University of California Institute of Library Research. February, 1970.

4. Cuadra, C. (ed.). ANNUAL REVIEW OF INFORMATION SCIENCE AND TECHNOLOGY. (4 vols.) published annually by Encyclopaedia Brittanica, Inc., Chicago, Illinois.

5. Borko, H. (ed.). AUTOMATED LANGUAGE PROCESSING. New York: J. Wiley, 1968.

6. Becker, J. and R. M. Hayes. HANDBOOK OF DATA PROCESSING IN THE LIBRARY. N. Y.: J. Wiley. (In press.).

7. Kent A. TEXTBOOK ON MECHANIZED INFORMATION RETRIEVAL. N. Y.: Interscience, 1966.

8. Lancaster, F. INFORMATION RETRIEVAL SYSTEMS: CHARACTERISTICS, TESTING, EVALUATION. N. Y.: J. Wiley, 1968.

9. Rosove, P. DEVELOPING COMPUTER-BASED INFORMATION SYSTEMS. N. Y.: J. Wiley, 1967.

10. Lefkovitz, D. FILE STRUCTURES FOR ON-LINE SYSTEMS. Washington, D. C.: Spartan Press, 1969.

11. Morse, P. LIBRARY EFFECTIVENESS: A SYSTEMS APPROACH. Cambridge, Mass.: MIT Press, 1968.

12. Hare Jr., Van Court. SYSTEMS ANALYSIS: A DIAGNOSTIC APPROACH. San Francisco, Calif.: Harcourt, Brace & World, Inc., 1967.

13. McMillan, C. and R. Gonsalez. SYSTEMS ANALYSIS: A COMPUTER APPROACH TO DECISION MODELS. 2nd Ed. Homewood, Ill.: Richard D. Irwin Inc., 1968.

14. Hayes, R. M. LIBRARY SYSTEMS ANALYSIS. In J. Harvey (ed.) DATA PROCESSING IN PUBLIC AND UNIVERSITY LIBRARIES. Washington: Spartan Press, 1966.

15. Sterling, T. and S. Pollack. INTRODUCTION TO STATISTICAL DATA PROCESSING, Englewood Cliffs, N. J.: Prentice-Hall Inc., 1968.

16. Lohnes, P. and W. W. Cooley. INTRODUCTION TO STATISTICAL PROCEDURES: WITH COMPUTER EXERCISES. N. Y.: McGraw-Hill, 1968.

17. Crow, E., Davis, F., and M. Waxfield. STATISTICS MANUAL. N. Y.: Dover Publications, Inc., 1960.

18. Pritsker, A., and P. Kiviat. THE GASP II PROGRAMMING LANGUAGE. Englewood Cliffs, N. J.: Prentice-Hall Inc., 1969.

19. Schriber, T. GENERAL PURPOSE SIMULATION SYSTEM/360: INTRODUCTORY CONCEPTS AND CASE STUDIES. Ann Arbor, Michigan: University of Michigan Press, 1970.

20. Seiler, K., III. INTRODUCTION TO SYSTEMS COST-EFFECTIVENESS, N. Y.: J. Wiley, 1969.

21. Gordon, G. SYSTEM SIMULATION. Englewood Cliffs, N. J.: Prentice-Hall, 1969.

22. Kunzi, H., Tzschach, H., and C. Zehnder. NUMERICAL METHODS OF MATHEMATICAL OPTIMIZATION: WITH ALGOL AND FORTRAN PROGRAMS. N. Y.: Academic Press, 1968.

Klat, Paul J.

1960 "Economics and manpower planning." Middle East Economic Papers-1960:55-64. American University of Beirut: Economic Research Institute.

Phillips, Doris G.

1959 "Rural-to-urban migration in Iraq." Economic Development and Cultural Change 7 (July):405-421.

Tannous, Afif I.

1947 "The tribal community in a nationalisite state." The Middle East Journal 1 (January):5-17.

1951 "Land reform: key to the development and stability of the Arab world" The Middle East Journal 5 (Winter):1-20.

Wardi, Ali

1966 A Study in the Society of Iraq. Baghdad: Ani Press.

**WESTERN MONTANA COLLEGE** A four-year college located in Dillon, Montana (pop. 4,548). ENROLLMENT: 904. INDIAN ENROLLMENT: 13. Eight Indian students have graduated in the past five years. The college employs four Indian staff members. TUITION: The extra out-of-state tuition is waived for Indian students, but they otherwise pay the same amount as other students. ADMISSION: A high school diploma, ACT and GED scores are required for admittance. SCHOLARSHIPS & FINANCIAL AIDS: Aid is available through the BIA and from tribal funds. Scholarships are based on need.

Contact: Admissions Office
Western Montana College
Dillon, Montana 59725



**WESTERN NEW MEXICO UNIVERSITY** A four-year university located in Silver City, New Mexico (pop. 7,751). ENROLLMENT: 1,333. INDIAN ENROLLMENT: 36. Twelve Indian students graduated from the university in the past four years. TUITION: Indian students pay the same amount as other students. COUNSELING: Anglo advisers are available to students of all ethnic origins, whether self-referred or referred at the discretion of a professor. ORGANIZATIONS & PROGRAMS: The Calumet Indian Club is open to Indians and non-Indians. Social events include Indian arts and crafts displays and Indian dances scheduled regularly throughout the year. EMPLOYMENT: There is an employment counselor for Indian students. CLASSES: Offered in the fields of history, anthropology, and sociology are courses dealing with Indian affairs and culture: History of the Indian, Modern Problems, Indian-White Relations, and The Southwestern Indian. Faculty are specially chosen to teach preparatory courses open to freshmen Indian students.

Contact: Mr. Nicholas Chintis, Director
Office of Admissions
Western New Mexico University
Silver City, New Mexico 88061

WESTERN WASHINGTON STATE COLLEGE A four-year college located in Bellingham, Washington (pop. 41,500). ENROLLMENT: 6,886. INDIAN ENROLLMENT: 80. One full-time Indian faculty member is employed by the college. TUITION: It may be waived for Indian students. ADMISSION: A high school diploma, College Entrance Examination Board scores, and GED are required for admittance. SCHOLARSHIPS & FINANCIAL AIDS: Grades and need are criteria for obtaining funds from the BIA. ORIENTATION: Indian students are expected to attend orientation sessions prior to registration in order to attain skill in studying, college social adjustment, and registration. REGISTRATION: Preregistration advisement is given Indian students by Indian advisers. COUNSELING: Anglo and Black counselors are available to all students regardless of ethnic origin. Students are referred at the discretion of professors. ORGANIZATIONS: The American Indian Student Union is exclusive to Indians. CLASSES & DEGREES: A degree is offered in ethnic studies, of which Indian studies is an essential component. Indian students are advised to register during the freshman year in preparatory courses in which the enrollment is reduced, the ratio of Anglo-Indian students is controlled, and for which the faculty are specially chosen.



Contact: Admissions Office
Western Washington State College
Bellingham, Washington 98225

# glossary

ACT . . . . . .American College Testing
BIA . . . . . . .Bureau of Indian Affairs
EOG . . . . .Economic Opportunity Grant
EOP . . . . . .Economic Opportunity Program
GED . . . . .General Education Development
GI . . . . . . . .Government Issue (Military)
GPA . . . . . .Grade-point Average
LEEP . . . . .Law Enforcement Education Program
NDSL . . . .National Defense Student Loan
SAT . . . . . .Scholastic Aptitude Test

# For more information

**Graduate and Professional School Opportunities for Minority Students**
Fourth Edition
Special Services Section
Educational Testing Service
Princeton, New Jersey 08540

**Graduate Study Opportunities for Minority Group Students**
Harvard/Yale/Columbia Intensive Summer Studies Program
1907 Yale Station
New Haven, Connecticut 06520

**New Careers in the Indian Health Program**
Public Health Service
Health Services and Mental Health Administration
U.S. Department of Health Program
Washington, D.C. 20013



**Scholarships for American Indians**
Bureau of Indian Affairs
Branch of Higher Education
123 4th Street, S.W.
P. O. Box 1788
Albuquerque, New Mexico 87102

National Indian Training Center
P. O. Box 66
Brigham City, Utah 84320
(A cooperative training program sponsored by the U.S. Civil Service Commission and Bureau of Indian Affairs)