An Overview of the Role of Math Courses for CIS Majors

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ABSTRACT

In this paper, an overview of the math course contents, knowledge and skills and trends should be required for CIS majors will be presented. A variety of math course developments will be discussed. Appropriate math course development provides a systematic, problem-solving approach to planning and designing learning experiences for CIS majors. It is imperative to explain the benefits that result from mathematics, discuss how its practitioners work, and present the rationale for CIS majors.

Keywords: CIS majors, math course, course design.

INTRODUCTION

Since late 1970s and early 1980s, personal computer goes into individual working settings and family life. Computer utilization and operation has no longer for computer professional only. Since then, a sub-division of compute sciences (CS) department, called computer information systems (CIS), has been growing to be an individual academic unit. The computer information technology major is designed to combine the benefits of a traditional college education with the benefits of hands-on training in state-of-the-art computer technology. Students become technically competent, but also learn to write well-organized and clear memoranda and reports. The computer information technology curriculum integrates technical skill with communication skills, superior general education requirements, and breadth of knowledge in the computer information technology field. In other words, from teaching and research standpoints, computer information systems education focuses on more the design for product-oriented and market trends. Computer science education is the discipline that seeks to build a scientific foundation for providing the underpinnings for today's computer applications as well as the foundations for tomorrow's applications. To this extent, computer science requires strong math disciplines and foundations. Computer information systems program only requires minimum math education. Computer information systems majors may not need as many math courses as computer science students need. Mathematics is the language of technology. It is used to formulate, interpret, and solve problems. It is the bedrock for the computer revolution. Mathematics provides us with powerful theoretical and computational techniques to advance our understanding of the modern world and societal problems and to develop and manage the technology industries that are the backbone of our economy.

Mathematics is a living discipline. Some traditional subjects in pure mathematics have been studied for hundreds of years; other topics, developed during the last few decades from the study of industrial issues, form a body of applied mathematics closely tied to the understanding of practical problems and basic phenomena. There is remarkable synergy between these seemingly disparate fields of study; the abstract nature of mathematics supports important applications in an ever-growing number of areas. However, how much knowledge is need for CIS students? How many math courses should be required for CIS students? What math course contents are needs for CIS students?

MATHEMATICS

Mathematics is an abstract science concerned with level and structure. It is best seen as a highly interrelated set of abstract systems, the structure of which is well understood. As such, it is perhaps the most advanced science. Other sciences use the concepts and structures of mathematics as tools to study real world problems. By mapping real world systems into abstract mathematical systems, the researcher facilitates the application of powerful mathematical results and methods. The broader our understanding of different mathematical structures, the better we are able to select appropriate models to study information systems phenomena.

In addition to the fact that mathematics is the most highly developed and powerful science, there are two other characteristics which recommend it to the study of information systems. As noted above, all disciplines contributing to information systems research use mathematics to some extent. It thus provides a common language for cross-disciplinary communication. Finally, the clarity, precision, and conciseness afforded by quantification are essential to the study of complex phenomena like information systems. Whitehead, in regard to mathematics, notes that a good notation spares us the painful necessity of thinking; notation itself may generate ideas. Mathematics has the most highly developed systems of notation of any science.

Mathematics tends to be viewed in a limited and distorted way by non-mathematicians. There is therefore a need to first outline the field of mathematics. Information systems researchers tend to identify mathematics which statistics. Statistics is just one of nine major branches of mathematics (Table 1). Although this may be the only branch of mathematics to which information systems researches are exposed, it is certainly not the only branch of potential use to information systems researchers. The over-emphasis upon statistics in the training of information systems researchers has resulted in a corresponding over-emphasis upon hypothesis testing and inductive methods in information systems research, almost to the exclusion of modeling and deductive approaches. Content analysis of the information systems research literature bears this out (Van Doren and Heit, 1973; Smale, 1981).

The range of potential applications of each of these nine branches of mathematics is limited only by our understanding of these areas of knowledge and out imagination. While each branch of mathematics includes very complex concepts and structures, each also includes quite simple and basic concepts that are within the grasp of virtually any information systems researchers. A good example is set theory's Venn diagram methods, now taught to grade scholars. A more recent development is set theory is the concept of "fuzzy set" (Zadeh, 1973), which offers methods of dealing with the many "fuzzy concepts" in information systems and leisure. Matrix algebra is important in solving systems of equations and provides the basic structure for many applied models, such as linear programming, input-output, and Markov chains.

Table 1. Areas of mathematics

1.	Logic and Set Theory
2.	Algebra, Group Theory, Matrix Algebra
3.	Geometry, Topology, Network and Graph Theory
4.	Differential Calculus
5.	Integral Calculus
6.	Real and Complex Analysis
7.	Probability, Game Theory
8.	Statistics
9.	Numerical Analysis

The mathematics of spatial structure including network and graph theory has many applications to transportation and communication flows, two very important dimensions of information systems. The calculus is one of the most powerful inventions of mathematics. It is difficult for me to envision anyone studying change without an elementary understanding of differential calculus. I would liken it to studying movement without having heard of the wheel.

Stephen Smith reminds me that probability is one branch of mathematics that has its roots in play behavior, and yet most information systems researchers pass all too quickly over probability to statistics, only to learn too late that one cannot fully understand statistics without first mastering the basic laws of probability. Probability and game theory have been applied extensively to management and decision making (Von Neumann and Morgenstern, 1953). Numerical analysis includes many techniques for approximation and estimation that will become increasingly useful to information systems researchers as quantification progresses.

While it may be impossible for a creation researcher to master all of these branches of mathematics in a single lifetime, an exposure broader than statistics is surely needed. We especially need to train future information systems researchers more fully in mathematics. I would recommend the following as a minimum for undergraduate programs in information systems:

1. A course in logic, perhaps in conjunction with philosophy of science.
2. A course in finite mathematics. This would include introductions to logic, set theory, matrix algebra, and probability with applications to linear programming, Markov chains, and the theory of games and decisions. Such courses are offered at most universities at the freshman level, and are required in most business programs.
3. One course in calculus
4. One course in statistics

I must emphasize that this should be a minimum for anyone training for a position in information systems management, administration, planning, or research. Quantitative skills will not be learned on the job, and when neglected in undergraduate education usually results in a lifetime of inadequacy and fear of mathematics. I do not believe there is a single information systems program in North America that meets this minimum requirement. Until we raise our standards in the quantitative area, our graduates will operate under a serious handicap, especially if they must compete with management and business graduates. Few will be adequately prepared to begin graduate programs or understand research.

Second courses in calculus and statistics are desirable, along with a course in mathematical modeling. Operations research, management science, and systems courses at this point in time can fill modeling needs until information systems-related modeling courses are developed. I suggest introducing these at the graduate level.

MODELING

This concludes a brief overview of mathematics. I will now move on to quantitative techniques in general. There is one important area of quantitative applications in information systems: modeling.

The term "model" is synonymous with the term "theory." In use, "model" is generally applied to mathematical models, while "theory" is reserved for more conceptual models in logical or verbal form. A model is simply a representation within abstract mathematical systems, basically mappings from the real-world system to the mathematical system. To be useful, a model must be less complex than the real system and must abstract its essential features. Achieving these two goals is the art and science of model building.

There are four important aspects of modeling that information system researchers need to understand:

1. How does one develop and test a model?
2. What are the different types of models?
3. For which kinds of problems is each model best suited?
4. What roles does modeling serve in information systems research?

Table 2. Classification of abstract models by attributes

1. Treatment of Time	: Static, Comprehensive Status, Dynamic
2. Treatment of Space	: Point, Area
3. Measurement Scales	: Discrete, Continuous
4. Recognition of Uncertainty	: Deterministic, Stochastic
5. Aggregation Level	: Micro, Macro
6. Form of Equation(s)	: Linear, Non-Linear, Systems
7. Inclusiveness	: Open, Closed
8. Flexibility	: Canned, Custom Built
9. Best Solution?	: Non-Optimizing, Optimizing

There are a variety of different types of models, including verbal, physical, graphical, and mathematical models. Mathematical models may be classified along nine distinct dimensions (Table 2). Models that have been applied in information systems tend to be (1) static, (2) linear, (3) deterministic, and (4) "canned." Since most of the phenomena that we study are dynamic, non-linear, and stochastic there is a need to develop more custom-built models to better suit our needs. It is particularly important that we recognize the dynamic and probabilistic nature of the objects of our study and use methods more suited to these properties. Our static, linear, deterministic view of the world is reinforced by the lack of time series data or longitudinal research, and ignorance of non-linear, probabilistic, and dynamic models.

CONCLUSION

As view of information systems research as processes will require all learner to take a broader historical perspective on the field, to develop new measures that better lend themselves to a process approach, to look more to mathematics, modeling and theory, and to take a longer range perspective on information systems research. It is necessary to spend more time and effort integrating what has been learned and making information research a cumulative process. Mathematics and quantification more generally, can help CIS move in these directions.

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