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Integrating Expert Systems Throughout the Undergraduate Curriculum

ABSTRACT: Over the years, there has been an increasing movement toward systemic reform in education. An important element of the educational process that seems to have been overlooked is the need to integrate subjects within some context or major issue. One of the essential components of this integration process is the recognition that expert/knowledge based systems technology can play a fundamental role as a strategic supporting science to help with the integration approach. This paper describes one novel attempt to integrate expert/knowledge based systems throughout the four years of the undergraduate curriculum in the new College of Integrated Science and Technology at James Madison University.

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INTRODUCTION

According to the U.S. National Commission on Excellence on Education (1983) and the American Association for the Advancement of Science (1989), reform of the United States educational system is greatly needed in order to produce a more flexible worker, one who would be able to adapt to the rapidly changing work environment of the next century. To produce a more flexible work force, reform movements suggest that mathematics, science, and technology education would better prepare students by teaching them the processes for developing lifelong learning skills. Specifically, integrated approaches to instruction where the boundaries between the scientific disciplines and mathematics are dissolved need to be developed so school curricula reflect the interdisciplinary nature of the real world. Development of these skills dictates a curriculum which is "process" driven rather than "content" driven.

At the new College of Integrated Science and Technology (CISAT) at James Madison University (JMU), its mission is to develop context-sensitive, collaborative problem solvers in science and technology. The central theme of accomplishing this mission is to integrate subjects and team-teach them within a specific context (e.g., the health care industry, the environment, manufacturing at work, etc.). Many individuals and scientists, like Harwitt (1994) who is Director of the National Air and Space Museum in Washington, D.C., feel that the educational process in U.S. schools is compartmentalized. There is a lack of integration of material across various subjects. Additionally, in science and technology-oriented courses, the material is not taught within a context--that is, typically equations and formulas are taught but the student does not have a chance to develop context-sensitive applications in which to better understand the use of these equations. Some Programs, like MIT's Integrated Studies Program which has transformed into The Institute of Learning and Technology (TILT) and CISAT's Integrated Science and Technology (ISAT) Program, have now been developed in order to stress the integrative approach to education.

The purpose of the ISAT program is to develop graduates who will be able to solve real-world, technological problems through a collaborative, context-sensitive approach. To begin this educational process, the ISAT undergraduate students enter three sequences of courses. The first series of courses is called "Analytical Methods" and is a sequence designed to provide the students with a set of analytic tools that they will need to both understand and analyze science-based problems. The second sequence of courses, "Issues in Science and Technology", is primarily designed to engage the student in the practice of science to motivate the student and provide understanding of some relevant and interesting science or technology issue. Secondarily, the Issues sequence is also used to introduce additional analytical methods. The third sequence of courses for the freshman/sophomore student is called "Connections." This set of courses provides the student with sensitivity toward the non-technological issues relating to technology problem solving for which the student must gain an appreciation. The course also contains elements which are intended to inculcate a sense of professional development in the student (Roberds, 1994). In the junior and senior years, the student takes courses in six strategic sectors (Energy, Environment, Engineering/Manufacturing, Knowledge Management, Biotechnology, and Instrumentation/Measurement), "majors" in a concentration, prepares a senior thesis as part of the concentration, and takes liberal education courses (throughout the four years)

An important part of this ISAT curriculum is the student's learning and use of expert and knowledge-based systems (Liebowitz,

1990, 1991, 1994; Medsker and Liebowitz, 1994) throughout the four years. Knowledge-based systems have been identified as an important strategic supporting science that can help in the knowledge sharing and reuse in the integration of the subject materials in the ISAT program. This paper will briefly describe how expert/knowledge-based systems are being integrated throughout the ISAT curriculum.

AN INNOVATIVE USE OF KNOWLEDGE BASED SYSTEMS IN THE CISAT CURRICULUM AT JMU

In Thomas Stewart's (1991) article, "Brainpower", he writes:

"Most companies are filled with intel ligence... The challenge is to capture, capi talize, and leverage this free floating brainpower. Every company depends increasingly on knowledge--patents, processes, management skills, technologies, information about customers and suppliers, and old-fashioned experience. Added together, this knowledge is intellectual capital."

The problem that Mr. Stewart addresses is the "real-world" issue of the way we train people to use knowledge--how we mix, match, and focus our knowledge. The traditional scientific and technical curriculum produces focused specialists, trained to think in a "vertical" manner. This is inevitably reflected, as Stewart points out, in the hierarchical construction of organizations and the way people operate in the workplace.

According to Wilcox (1993), we have not developed satisfactory fundamental paradigms in a world that is increasingly interdisciplinary. We must re-think the entire enterprise of higher education or American schools will go the way of many American industries that have faded with the waning of the 20th century.

"Knowledge-based systems" have been identified as a critical component of the undergraduate and graduate programs in CISAT at JMU. This area is a core element and important strategic science that is being interwoven throughout the approved four year undergraduate (B.S.) curriculum and the proposed M.S. program in Integrated Science and Technology (ISAT).

In the undergraduate ISAT curriculum, knowledge-based systems are being integrated throughout the four years. The model of "vocabulary/concepts-building skills-using/application skills", as pertains to knowledge-based systems, is being applied throughout the curriculum. In the first year, the students are introduced to the vocabulary and concepts of knowledge-based systems, mainly through the Analytical Methods courses (see the Appendix). The students learn about modeling using qualitative factors and experience, which segues into the discussion of decision support systems and expert systems. In the second year, the "building skills" associated with knowledge engineering are learned by the student. In the junior and senior years, courses in various "strategic sectors" are taken by the student (e.g., energy, environment, manufacturing, knowledge management, biotechnology, etc.). In these years, the students are exposed to using knowledge-based systems as applied to their strategic sector courses (e.g., using expert systems for environmental applications, etc.). As a result of this effort, a library of expert systems applications in the various strategic sectors is being built for easy access and use by the student.

CISAT has just completed its first class of freshmen. We spent four intensive weeks in a module creating an awareness of expert systems for the students and acquainting them with the knowledge engineering process. The students also had a chance to develop simple expert system prototypes as either a career path advisor, college selection advisor, or a "concentration/major field" advisor. The class also had used expert systems for a number of applications (environmental, structural analysis, banking, tourism, medical, etc.) in order for the students to better appreciate the value of expert/knowledge-based systems technology. Additionally, we had developed an interactive multimedia aid called "Developing Your First Expert System Prototype" using the multimedia authoring software, Compel, on the IBM PC, and the students used this system to help them learn about the knowledge engineering process. After the four weeks, we felt satisfied that the students felt fairly comfortable with the vocabulary and major concepts associated with expert systems development. In the sophomore year, the students will obtain a more detailed description of the knowledge engineering methodology, and they will apply expert/knowledge-based systems to energy, environmental, biotechnology, manufacturing, and other application areas during their last two years. If the student is very interested in knowledge-based systems, they can concentrate (as a major field) in knowledge management in their junior / senior years.

KNOWLEDGE-BASED SYSTEMS: A CRITICAL CORE AND UNIFYING THEME IN THE M.S. PROGRAM

The undergraduate ISAT program is using knowledge-based systems as a critical technology area, and the proposed M.S. program in ISAT will also use the integration of knowledge-based systems, or some might say "knowledge technology", as a major thrust throughout the curriculum. The importance of this technology is highlighted in the words of Tom Peters (co-author of "In Search of Excellence") which appeared in the preface of *The Rise of the Expert Company:*

"I conclude that any senior manager in any business of almost any size who isn't at least learning about artificial intelligence (AI/knowledge technology), and sticking a tentative toe or two into AI's waters, is simply out of step, dangerously so."

In today's environment, organizations are downsizing, reengineering, and flattening the management hierarchy. As a result, many middle and senior managers are leaving the company, either due to early retirement or attrition. These individuals are taking their many years of knowledge and experience with them, resulting in an inability to build up the institutional memory of the organization. This phenomenum is happening worldwide in all kinds of businesses--engineering, manufacturing, chemical, financial, and many other types of businesses. In order for U.S. industry to succeed, we must capture and distribute this knowledge and experience to others, so we can rapidly learn from our experiences. Knowledge-based systems (knowledge technology) are ideal for accomplishing this task in preserving the corporate memory of the firm.

In the M.S. program (like the B.S. program), knowledge-based systems will be integrated into the coursework using the following triad: vocabulary-concepts/building skills/applications. The pervasive use of knowledge-based systems is unique and sets the M.S. program apart

from related degrees. In the core course on "Knowledge-Based/Intelligent Systems", the students will learn the vocabulary, concepts, and skills associated with knowledge engineering. In the other core courses, the applications of knowledge-based systems will be integrated into the courses, such as using expert systems in manufacturing or environmental applications.

A central theme throughout the M.S. program which comes directly from the knowledge-based systems field is the concept of knowledge acquisition. This involves acquiring knowledge from different sources--experts, handbooks, regulations, manuals, etc. Knowledge acquisition involves the ability to conceptualize, analyze, and model how a particular function or task is performed. The techniques used in knowledge acquisition (structured interviewing, protocol analysis, observation, repertory grid analysis, card sorting, etc.) can be universally used in most domains including science, engineering, technology, education, and the like. Knowledge acquisition is also one of the pillars of knowledge-based systems, and usually is the bottleneck in building the knowledge-based system (Scott et al., 1991). In the M.S. program, we would apply the various knowledge acquisition techniques throughout the courses to help the student better understand the scientific and technological domains and to facilitate the student's ability to communicate and interact with others.

SUMMARY

This paper stresses several points. First, expert/knowledge-based systems technology is a critical strategic supporting science. Second, more schools should recognize the importance of knowledge technology and should expose the students to this core area. Third, as a critical strategic science, knowledge-based systems should be "integrated" throughout the undergraduate and graduate curriculum, in terms of the model of "concepts, building skills, and applications". Last, CISAT at James Madison University is trying to play the lead role in integrating knowledge-based systems throughout the curriculum.

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Dr. Jay Liebowitz is Professor of Management Science at George Washington University. He recently was on leave as Visiting Professor in the College of Integrated Science and Technology at James Madison University. He is the Editor-in-Chief of the international journal, Expert Systems With Applications, published by Pergamon Press. He is the Chairman of The World Congress on Expert Systems, and has published 16 books and close to 200 articles, mostly dealing with expert systems.

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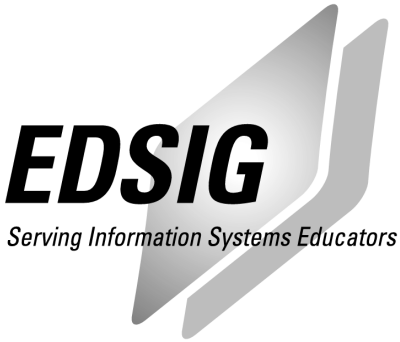

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