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Strategies for teaching information systems

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Abstract: This paper aims to provide insights into strategies for teaching information systems. Key strategies discussed include the development and use of computer case studies, interviewing corporate information systems management, use of appropriate guest lecturers, project work within organizations, and research into current technology issues. These strategies are illustrated with reference to the teaching of two postgraduate subjects. New technology may be appropriated to the teaching of information systems namely the use of Self-Monitoring And Reactive Tutoring Systems (SMARTS). These systems will include elements of intelligent tutoring systems, artificial intelligence, hypermedia, information tracing and students' thought processes. A framework outlining the objects or elements of a SMART and their relationships is presented as an initial guide to researchers interested in further development of these technologies. Mention is also made of an experiment underway in the USA on customized text book publishing which provides tailored resource material chosen by the lecturer for a particular subject which is then published as the customized text for that subject.

Introduction

Information systems is a growing profession where the industry's need far outstrips the supply of qualified personnel. This pressure feeds back into the educational system where information systems educators often have to cope with increasing numbers of students, often with little increase in either staffing or ancillary resources. Another driving force in the equation is the rapid developments in technology which give rise to changes in the existing subject content, and the development and implementation of new information systems subjects.

Further pressures from educational regulators and university administrators via the academic promotions and counselling system, require that academics perform as teachers as well as researchers. These pressures encourage academic educators to be innovative and to use both organizational and technological solutions to help improve their teaching methods and increase the quality of the final product – our students.

This paper discusses current teaching strategies for achieving a goal of producing quality information system students, and highlights future strategies for using technology to provide Self-Modifying And Responsive Tutoring Systems (SMARTS) and for customized text book publishing.

Current strategies

This section of the paper will discuss current strategies for teaching information systems (IS), illustrating the concepts with experiences drawn from teaching two Masters' level subjects, namely IS Audit and Knowledge Based Information Systems, at the University of New South Wales.

A brief outline of the aims of the two subjects is set out below. The IS Audit course aims to provide the student with the required theory and practical hands on experience necessary for auditing complex application systems and environments. Topics covered in the course include IS audit management issues, installation and environment audit concerns, application systems development and operational audit, use of basic and advanced computer assisted audit techniques, audit of complex environments (databases, distributed systems and telecommunications), and audit of emerging technologies such as expert systems and EDI.

Knowledge Based Information Systems (KBIS) aims to provide the student with both the theory and practice of designing, implementing, and managing commercial expert systems developments. Topics include hardware and software environments and tools, knowledge acquisition, methodologies for KBIS development, knowledge representation, inferencing and control, validation, management of KBIS development, and discussion of associated advanced technologies (for example, neural networks and hybrid expert systems).

Further details of the teaching strategies used in these subjects will be provided in the following sections.

In order to place the strategies in perspective it is appropriate to put them in the context of adult learning principles derived from educational and cognitive psychology literature (IBM, 1987). Some of these principles include:

(1) problem solving oriented rather than subject oriented;
(2) immediate application via concrete exercises;
(3) learner control over the learning process;
(4) active participation in the learning process;
(5) integrate holistic/analytical thinking through, for example, situation analysis;
(6) individual learning rates and styles;
(7) use meaningful instructional cues;
(8) checking for understanding;
(9) feedback via consistent information on progress – credit and recognition for success and remediation for errors.

Realistic computer case studies

For most subjects taught in IS curicula, case studies should be used as a teaching strategy. For IS Audit, students required hands on experience in reviewing application systems and interrogating system databases and files. A review of the available software and applications in the early 1980s revealed no software that would satisfy the subject's objectives. As a result, the author obtained commercial micro computer software from a developer with both the source and object code. This was necessary to enable modifications to be made to the programs, namely to:

upgrade or degrade systems functions and controls;
build in audit features;
include fraudulent modifications.

Eventually a payroll package was purchased and later a range of accounting software was obtained. This range of software provided the IS Audit course participants with a variety of application review case studies. The payroll software obtained was modified and developed into Micro Information Systems Audit Training (MISAT) resources to provide the following overall objectives:

(1) review and evaluate an application system using the MISAT resource in a team situation. This involves the testing and critical appraisal of application controls, weaknesses and writing comprehensive reports to client management;
(2) design and use of an embedded on-line monitoring audit technique, i.e. a system control audit review file, using MISAT, for the particular application system under consideration;
(3) development and use of a micro audit retrieval package to interrogate and analyse case studies' data files, involving such techniques as file totalling, exception analysis, audit sampling, parallel simulation and period file comparisons.

More detailed objectives for each case are included in Appendix 1.

These case studies undertaken by students in a micro-computer laboratory helped to satisfy learning principles 1,2,3,4,5 and 7 as outlined above. Feedback from students via end of course evaluations demonstrated that students considered the on-line case studies an effective learning mechanism. The MISAT case studies were subsequently packaged and licensed by some government departments (for example, the Australian Audit Office) for use in their training curriculum.

Interviewing IS management

One very effective strategy was to involve students in interaction with management to discuss problem areas and for students to see and hear practical solutions to those problems. This strategy was used in the IS Audit course by encouraging interaction with IS management through arranging on-site inspections of medium to large commercial IS installations having a mixture of hardware, applications and telecommunications. Students were given a presentation on the management structure, an overview of the installation and applications, an on-site inspection of installation facilities, and then an opportunity to interview (in a group) parts of the IS management team. Team involvement varied but included the IS Manager, Systems Development Manager, Operations Manager, Database Administrator, and Telecommunications Manager. During this interviewing period, students were taking part in a realistic (although simulated) installation audit, and found IS management frank in their replies and opinions on control and security in their installation environment.

The students prepared installation audit reports on management of the major control strengths and weaknesses in the installation together with their recommendations for improvement. A selection of reports were communicated back to the organization's IS management who were impressed with the students' analysis and recommendations given the limited time frame for this exercise compared with that of a commercial installation audit.

This exercise proved invaluable to the students who appreciated the opportunity to interact with IS management and the chance to perform a virtual live installation audit. Learning principles 1,2,3,4,5,6,7,8 and 9 appear to have been satisfied by this strategy.

Group project work

A successful learning strategy is the group project, which is applicable across many subjects in the IS curriculum. This closely parallels the working life of an IS professional who is often required to work on projects as part of a team. Skills in team organization, motivation, planning, coordination, monitoring and

management are learnt via direct involvement in the group and through regular group meetings with the lecturer in charge. In IS Audit, groups were formed to undertake the application audit review case and management reporting. In Knowledge Based Information Systems, groups were formed to undertake a major assessment task – the design and implementation of a KBS prototype. This involved group work over the whole session with an external organization's expert and going through the processes of knowledge acquisition, KB design, and KB implementation of a KBS prototype. During the course of the group work exercise, the groups were responsible for handing in interim and final design reports and copies of the prototype, developing a user run manual, and performing and documenting a formal evaluation of the prototype by the expert. In addition, groups tried to present their systems formally, in both trial mode with a critique by the lecturer in charge, and in a final form to a panel of KBS managers from industry and commerce, as if they wished to convince management to take their prototype to a production version. The presentations involved all group members, included a demonstration of the prototype, and counted towards the final project mark. Previous industry panel members have commented on the high quality of the presentations and the developed prototypes. In fact, some have been taken up by the organizations involved and developed into production versions, for example Raider an internal audit KBIS (Caddy *et al.*, 1990).

These group work tasks also satisfy the learning goals of having students being able to communicate effectively, both in oral and written form. The industry and commercial support for these group projects is greatly appreciated. Learning principles 1,2,3,4,5,6,7,8 and 9 appear to be satisfied by this teaching strategy.

Guest lecturers

This strategy of using guest lecturers for IS subjects is employed where the subject matter in the course lends itself naturally to this topic or where the lecturer's knowledge is limited in a particularly new area of IS technology. For example, in KBIS a guest lecturer (a manager of a Knowledge Engineering Group for a large bank) was invited to discuss the topic area of managing KBS development. While the theory could have been covered by a normal lecture or seminar, the benefits of the manager's practical experience in this area were invaluable to the students. Likewise, in KBIS a guest lecturer (Neural Network practitioner) was invited to discuss a new area namely Neural Networks and their relationships to expert systems. This was an area where the lecturer had limited exposure, and where the practical experiences in implementing this technology, together with its associated advantages and limitations, were adequately communicated by the guest lecturer.

While this strategy only covers learning principles 6 and 7, the added advantage of variety in lecturing styles and a change of pace helps to keep student interest, involvement and participation high.

Technology research

An important teaching strategy is the involvement of students in active research into a current audit problem area, situation or issue. This strategy has been successfully used in IS Audit where students carry out research into a current technological IS audit issue in either a team or individual situation. The students carry out a literature review of the area, develop a normative position, carry out active case study research by involving an external organization, and review its implementation and use of the technology against the normative position. The literature review, case write-up and analysis together with recommendations for improvements are presented in a technology research report which is communicated back to the participating organization. Some of the research projects completed to date include:

(1) Data Base Management Systems Audit Reviews;
(2) Security Access Control System Reviews;
(3) Audit Automation;
(4) Audit of Expert Systems;
(5) Audit of Electronic Data Interchange.

To encourage students in their research project efforts, the EDP Auditors Association, Sydney Chapter, has instigated an Annual Prize for the best research project in IS Audit. The support from the EDP Auditors Association, the audit profession and participating organizations is greatly appreciated. This type of research is beneficial both for the students and the academic as joint publications may result (Jamieson and Szeto, 1989a, 1989b).

The effectiveness of this type of learning experience is highly rated by the students in their course evaluations and has often enhanced their job prospects or promotional opportunities. Learning principles 1,2,3,4,5,6 and 7 appear to be satisfied by this approach.

Future strategies

The preceding sections focused on past and current strategies for teaching IS. The following sections highlight new technological developments of which IS academics should be made aware, and which may be taken advantage of in the future when teaching an IS curriculum.

Getting 'SMART'

Challenges arise in the teaching of IS due to the variation in students' skills, backgrounds, and motivation to learn at both the undergraduate and postgraduate levels. As academics we face the challenge of motivating an entire class to develop their skills, especially in critical thinking and analytical abilities, so that they can make effective judgements in practice. For example, IS Audit students making judgements about the reliability of the system of internal control in a complex IS environment. Setting the correct pace of learning materials is important. A second challenge relates to the need for better information about students' learning needs and effectiveness of instructional efforts to fulfill these needs, thereby allowing a better fit between course contents and structure, and student needs.

One way of providing assistance to classes with large student numbers or where distance learning is appropriate is to use Computer Aided Instruction (CAI) or Computer-Based Training (CBT) methods. CAI combines computer technology with various media to tutor a person in a special topic area. CAI has a history dating back to the 1960s and perhaps the best known of the early mainframe applications is the PLATO system developed at the University of Illinois which is still in use. The introduction and proliferation of the micro computer in classrooms have increased the opportunities to use CAI at all levels from primary to graduate schools (Niemiec and Walberg, 1988). However, these methods have limitations which will be discussed shortly. CAI is now evolving from a relatively simple but tireless tutor characterized by a repetitive (and linear) representation of a topic towards an effective and efficient device in the development of critical thinking and analytical capabilities. As Woolf (1988) believes, we are on the verge of developing substantially more powerful tutoring systems that will reason about a student's knowledge, monitor their solutions, and customize the software's teaching strategies to the student's learning patterns.

SMARTS are proposed by the author as feasible system developments given current and known future technology. They may be formed using a combination of hardware, authoring software, artificial intelligence techniques, hypermedia, information trace facilities, and student thought processes and comments. They provide the facilities to evaluate and diagnose users' information needs, assess and improve users' skills in critical thinking and judgement, aggregate information across individuals to provide a needs assessment of a particular group of users, and provide new knowledge through traditional CAI or CBT interfaces. The remainder of this section will discuss the evolution from primitive CAI to SMARTS and the driving forces behind this proposed development.

Limitations of CAI

Traditional CAI guides the student through the learning material by a series of questions displayed on the screen. Correct responses are followed by a display of the next frame of material and related questions. Incorrect responses lead to a re-display of previous supporting material and the same question. This iterative loop continues until all questions in the domain material have been correctly answered. Dreyfus and Dreyfus (1986) contend that this sort of CAI is poorly suited to the transmittal of higher order problem solving abilities or complex skills. This calls into question the effectiveness of CAI for the following reasons:

(1) encourages a passive approach to learning characterized by an absence of student initiative or creativity (Jonassen, 1988; Sleeman and Brown, 1982);
(2) inability of most applications to comprehend or respond to students' natural language patterns thereby limits CAI to highly structured, multiple choice type formats. This reinforces passivity and renders evaluation of student judgement or analysis extremely difficult (Wyber, 1987);
(3) the perception of system rigidity from the student viewpoint perhaps stifles student motivation and may frustrate or deter use of CAI by instructors (Wyber, 1987);
(4) unanticipated answers are not dealt with and remedial paths are similarly rigid which may lead to creative solutions by students being unrecognized, even 'punished', or inappropriate remedial paths being set (Jonassen, 1988);
(5) misfit between the student's capabilities or level of sophistication and the difficulty of questions (Sleeman and Brown, 1982).

Development of intelligent computer aided instruction (ICAI)

These short comings led to the use of artificial intelligence (AI) principles to develop a model of the users' thinking processes and the advent of intelligent computer aided instruction (ICAI) (Wyber, 1987) or intelligent tutoring systems (ITS). ITS are designed to represent both the concepts to be taught and how a student might learn these concepts (Woolf, 1988). ITS use expert systems, pattern recognition and natural language understanding to help analyse student responses (whether multiple choice, narrative or diagramatic) to determine the closeness of fit to the correct answer. It is this closeness of fit that indicates something about the student's judgement process to which the ITS can respond in subsequent frames.

Despite promising developments in natural language interfaces, most ICAI programs still constrain natural language usage. Although more

sophisticated in their diagnostic capabilities, they still assume particular conceptualization and thinking processes that may be inappropriate for some users. Although more flexible, they still may be too easy or too difficult for some users.

The addition of hypertext and information tracing to ICAI helps to overcome these limitations and produces a system with the capacity for self monitoring (Gray and Jacobi, 1990).

Adding hypertext

A hypertext system (Nelson, 1965; Engelbart and English, 1968) can be conceptualized as a network of index cards where the cards are nodes in an associated, network based structure. Its distinction from other forms of storage is the associative structure used that closely models the structure of human memory. Traditionally the hypertext system was textual, however, with current developments in technology a hypertext system can contain hypermedia – a mixture of text, graphics, live or still video images, sounds and music.

Hyperwords are labels which uniquely identify a node which contains a chunk of information. Hypertext systems have built-in browsers which are a set of commands or techniques for students to navigate the links between nodes in the network. The nodes are linked by including references to other nodes and are traversed by the student selecting from highlighted hyperwords or from a menu of hyperwords. Adding this hypertext capability to an ITS provides the students with freedom to navigate through the tutorial information independent of the main path driven by a series of questions, and to the depth required to satisfy their understanding.

Thus, adding hypertext capabilities increases the academic's ablity to target learning materials at the appropriate level of difficulty for the students, and permits a more personalized, flexible and active approach to learning by the user. Thus overcoming the criticisms of rigidity of format and remedial paths, passivity of the student, and lack of accommodation of a variety of reasoning and problem solving styles.

Adding information tracing

Adding information tracing will further increase the effectiveness of ITS. Payne and Braunstein (1977) report on one of the early uses of a computer controlled retrieval system (CIRS) to trace information acquisition. With a CIRS a student or research subject interacts with a computer and requests chunks of information about a particular problem domain. The computer maintains a log that traces the information acquisition strategies of the student. Bedard *et al.* (1984) report one of the first uses of a microcomputer based CIRS to capture auditor information search patterns.

A more sophisticated CIRS research tool, called a Knowledge Acquisition System Evaluator (KASE), is discussed by Jamieson (1990). This tool collects other subject parameters such as the amount of time a subject reviews a piece of requested information – the longer the person studies the information the more important or difficult that information is presumed to be. The path through the case is also important to researchers and teachers as it indicates different search strategies, either a systematic search following the natural sequence or a directed search, in order for the subject to reach a decision (Biggs and Mock, 1983).

Background data on the subject can also be collected and analysed to identify relationships between the information traces and the subjects' characteristics (for example, expertise or skill level, background, educational information, work history). For example, Bedard and Mock (1989) compared information search strategies among auditors at different skill levels (expert and novice) using a CIRS.

Gray and Jacobi (1990) propose Self Monitoring Intelligent Tutoring Systems (SMITS) which include the addition of hypertext and information tracing techniques to an ITS. They believe that, from a developer's perspective, the information trace can be used to help evaluate the efficiency and effectiveness of a SMITS. By reviewing the information traces of a test group of students, the developer can see whether the placement of the information frames in the hypertext network are at the correct level in the hierarchy thereby optimizing the SMITS design before the final production version is completed and distributed. Gray and Jacobi (1990) believe that, from a users perspective, information trace provides help in diagnosing the educational needs of individual students and then tailoring specific programs or training for that individual. Also, the traces provide the opportunity to aggregate evaluative information across multiple individuals to identify trends in performance and to plan formal curricula. Educational researchers may also benefit by the use of the pattern matching of information search traces with user characteristics.

Adding student thought processes and comments

The author proposes a conceptual system called SMART which includes all the conceptual components of a SMITS but includes facilities for capturing students' thought processes when solving problems presented to them by the SMARTS, and the ability to give comments to the instructor or developer at any stage during the case solving process. Jamieson (1990) in his KASE prototype has implemented such a function which is also included in the information tracing process. A student or research subject may provide a rationale for why a particular decision was reached, immediately after the decision has been

made. This immediate protocol is currently in written form in a window provided to the subject on request, but is not limited to text as facilities are now available to capture and analyse voice input (for example the Mac Recorder). The use of discourse analysis (Frederiksen, 1988) and AI techniques may be used to analyse these students' thought processes which may give more insight into the students' understanding and problem solving processes. Likewise students' comments, at any point in the case solving process, allow for immediate feedback to the academics or authors of the SMARTS which would be useful for understanding errors or bugs in the system which have been detected by the student and highlighting of student's suggestions for improvements.

Figure 1 provides a conceptual model of the suggested SMARTS and Figure 2 provides a component architecture for the SMARTS.

Customized text book publishing

Discussions with University of Southern California (USC) IS academic staff last month, which are

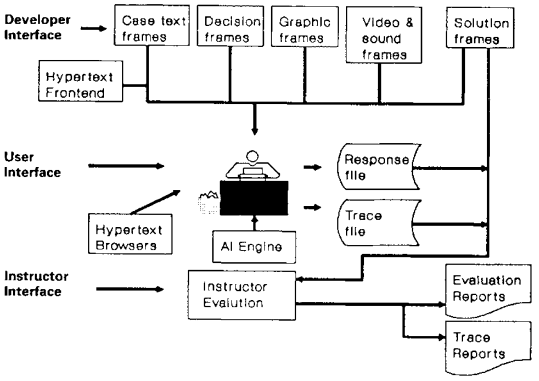

Figure 1 SMARTS – conceptual model

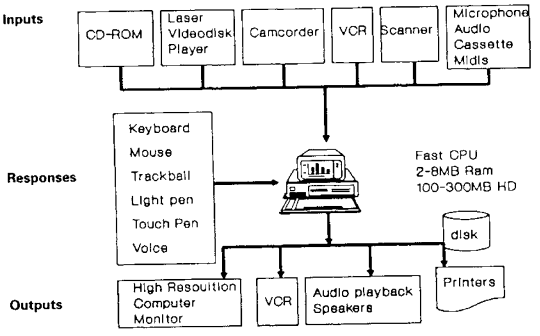

Figure 2 SMARTS – component architecture

confirmed by Teitelbaum (1990) and McGraw-Hill World (1990), reveal that McGraw-Hill has designated USC to be its first test site for a joint venture in computer-driven, customized text book publishing. This will allow IS academics to select objects of information from a variety of sources, including text books (say one or two chapters), periodicals and databases, and then combine and print enough of them for the needs of a particular subject offering in a session.

Three essential elements of the research project include – the USC academics and McGraw-Hill editors who will evaluate and develop course materials using McGraw-Hill's Custom Publishing base; the USC University Bookstore which will open the USA's first on-site Custom Publishing Centre in January 1991; and the Research partnership which will explore ways to link the Custom Publishing System with USC's library facilities and research programmes. This information network will serve as a model for similar networks across the USA and, hopefully, Australia. This will permit students, academics and other staff to access information by computer from libraries, offices, classrooms and distance learning centres.

As academics, we will now be able to design customized text books by selecting from a catalogue of on-line information resources. These will then be run off by optical scanning, high-volume laser printers located in the Custom Publishing Centres (the University Bookstores), who will also handle royalty and licensing rights associated with the publications. Advantages accruing to academics from such a move include the inclusion of previously unpublished material, the ability to update reference and teaching materials easily, books never going out of print, the elimination of middlemen (e.g. shippers) and the fact that books will never be out of stock or contain irrelevant material from an instructor's viewpoint. This approach also formalizes the legal and illegal practices that have existed with informal manual custom publications in the past. Our students should benefit by having a customized text book (no unused chapter), hopefully, at a realistic price.

Discussions with personnel from McGraw-Hill Book Co. Australia Pty. Ltd. indicate that, should the research trials with USC prove successful, there is a very good chance that the system will be implemented world-wide. Australian IS academics may then take advantage of this technology to improve our courses.

Conclusion and future research issues

The two future technologies presented above present challenges for IS educators, and raise many research

issues that need to be addressed. With customized text book publishing, Teitelbaum (1990) mentions that these include the research and analysis of:

(1) curriculum benefits of customized publishing;
(2) benefits and limitations of on-line full text retrieval access for student and academic research;
(3) advantages for library access and holdings;
(4) impacts of these technologies on the cost structures of publishers and libraries;
(5) implications of custom publishing for copyright and licensing;
(6) impacts of electronic production and distribution on bookstore operations and relationships.

This paper has described the components of a conceptual SMARTS. Future research is required to construct such systems and to evaluate their effectiveness and efficiency. Cost may be a significant factor in the use of this technology as some components are quite expensive. However, these costs may be dwarfed by the costs of implementation: for example, interactive video production and editing which can cost up to $200 000 for a 40 minute video; and the time for programming a SMARTS. However, these costs and limitations should not deter implementation efforts.

The current key strategies discussed in this paper have all worked to stimulate the learning process in students and have been judged by them as effective in course evaluations. SMARTS and customized text book publishing have been put forward as two ways that may prove effective in preparing and teaching IS in the future, given the pressures of the current tertiary educational system and in the changing circumstances of continuing professional education.

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Appendix 1

Information systems audit case studies

Each case study includes:

(1) the case study environment and assignment;
(2) suggested solutions;
(3) micro software (source code included);
(4) test files.

While these case studies progressively build on each other they may also be used individually. Presentation of the case studies may be by formal course or by stand alone self-study modules.

The case studies provide:

(1) familiarity with an interactive accounting application;
(2) controls review of the application;
(3) use of the test data method;
(4) involvement in systems development;
(5) design and use of a password security access system (includes encryption);
(6) design and use of an imbedded audit technique system control audit review file (SCARF);
(7) use of micro audit retrieval system to perform audit tasks which include file totalling, exception analysis, audit sampling, parallel simulation and period file comparisons.

Objectives of case studies

Case study no. 1 – payroll application review

(1) Provide familiarity with interactive accounting software;
(2) Consider payroll system risks and exposures;
(3) Determine payroll system audit/control objectives;
(4) Evaluate system's operations and controls;
(5) Evaluate system's security and auditability;
(6) Use test data method;
(7) Identify system weaknesses and make recommendations;
(8) Report system review findings to management.

Case study no. 2 – on-line audit monitoring system

(1) Provide opportunity for auditors to undertake systems development audit tasks and to use advanced audit techniques;
(2) Design a password security access system with encryption for the payroll system;
(3) Design an imbedded audit technique (system control audit review file) for the on-line capture and reporting of management and audit information;
(4) Specify audit parameters for use by the SCARF system;
(5) Use of both the password security access system and the SCARF system to provide audit information.

Cast study no. 3 – micro audit retrieval software

(1) Provide opportunity for auditors to use audit retrieval software;
(2) Specify micro audit retrieval software audit objectives;
(3) Design the micro audit retrieval software;
(4) Specify audit parameters for an effective audit of the payroll master files;
(5) Provide micro audit retrieval software to implement audit objectives using specified audit parameters.

Biographical notes

Rodger Jamieson is director of the Centre for Information Technology Research, University of New South Wales. He is a qualified Chartered Accountant member of the Australia Computer Society and a Certified Information Systems Auditor from the EDP Auditors Association (USA). His prior experience includes computer security and audit consulting for Touche Ross and Coopers and Lybrand as well as commercial experience with the AMP Society and Honeywell. His main areas of research and publication are EDP security and audit and expert systems. He has lectured widely to professional bodies, tertiary education institutions, government and the federal police in these areas.

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