SOLAR: A CASE-ORIENTED DECISION MAKING PROGRAM IN RADIOGRAPHY

Peter Wells and Marilyn Baird

ABSTRACT
In many professional disciplines, the creation of meaningful learning contexts in order that students can form the essential links between the academic program and the practitioner's experience, is a huge challenge for educators.

In the 4-year degree course in Radiography & Medical Imaging at Monash University, this challenge has been met in part by building into the curriculum case-oriented learning activities. Originally paper-based, these have now been brought together in a computer program called SOLAR (Student Oriented Learning About Radiography) designed to be used by on-campus as well as remote, distance education, students. SOLAR was introduced at the second year level in 1999 and its early development was described at CBLIS'99. This paper tracks the further development of the SOLAR project and reports on the students' acceptance of this mode of learning.

KEYWORDS
Case-oriented learning, clinical decision-making, medical sciences, distance learning

INTRODUCTION

Since the reorganisation of the medical curriculum at the turn of the twentieth century, users of medical services have expected practitioners to base their actions upon a sound knowledge of scientific facts, theories and principles. However, research continues to confirm that practitioners from a number of health professions, including medicine and radiography, rely more upon their clinical experience than the latest scientific research to inform their practice (Mathews and Rogers, 1984, 1988; Heggie, 1990; Balla et al, 1990; Rosenberg and Donald, 1995; Baird, 1998; Trede 2000). This is not surprising given that since Dewey it has been accepted that experience is the foundation of education, learning and knowledge. Yet experience is not synonymous with best clinical practice. As proponents of evidence-based medicine argue, the patient or client is best served when practitioners reflect their clinical expertise against "external evidence gained through focused review of the research" (Wood, 1999).

This paper describes the computer-based, case-oriented program called SOLAR that has been created to facilitate the integration of research findings with clinical expertise in the minds of undergraduate students. An early version of this program was presented at CBLIS'99 (Wells et al, 1999). SOLAR is predominantly about getting students, individually or in small groups, to make the all-important link between science and clinical decision making.

SOLAR presents to students the description of a case, or scenario, drawn from real life by professional radiographers, and then requires them to construct a clinical action plan (CAP) that is eventually compared with that prepared by an expert. The scenarios at present range over most of the radiographic modalities and also include aspects of professional role development, radiation safety and quality control and assurance.

The provision of the expert CAP for each scenario is a central feature of SOLAR. Expert CAPs can clear up student misunderstandings about the nature of a clinical problem and introduce them to the complex nature of their profession and the risks a patient might face if examined by a practitioner with inadequate knowledge and skills. This is accomplished at minimal cost using the SOLAR browser. The browser designed for SOLAR also renders it appropriate for other health professions and currently work is in progress on a case-oriented learning program for dietetics and nutrition. The SOLAR database is also being used as a template for other CD-ROM projects to be used within the Faculty of Medicine at Monash (this is described in another paper at this conference).

This paper is organised to present the augments to support case-oriented learning, describe the central features of the SOLAR program and the range of scenarios that are currently used, illustrate the use of SOLAR by second year radiography students and discuss the results of a student survey.

CASE-ORIENTED LEARNING IN RADIOGRAPHY

All graduates from Monash University are expected to have the capacity to engage in lifelong self-directed learning, to seek imaginative solutions to real-world problems, to demonstrate the knowledge, skills and attitudes expected of a professional whilst anticipating and understanding the wider social and political implications of their actions. Clearly, if students are to achieve these learning outcomes a variety of teaching and learning experiences need to be developed.

Thus there are a number of reasons why the Department of Radiography & Medical Imaging, in collaboration with the School of Physics & Materials Engineering, implemented a case-oriented approach to learning and teaching in radiography. First, the approach accords with constructionist notions concerning the process of knowledge creation, and that these are slowly beginning to influence university curricula (Murphy et al, 1998; van der Vleuten et al, 2000). This is leading to a change, a reconceptualisation of teaching as the facilitation of student learning.

Second, research into clinical decision-making continues to emphasise the crucial role discipline based knowledge plays in effective professional practice (Eraut, 1992; Higgs, 1992; Baird, 1998). Expert practitioners are experts not just because they have “seen” it all before, but “by the ready availability from memory of appropriate knowledge to resolve the problem” (Norman, 1988). At the same time, research utilising qualitative methods of data collection and analysis reveals that expert practice is also dependent upon previous experience and reflection upon that experience, “intuition”, “improvisation” and “professional artistry” (Schon, 1983; Fish and Twinn, 1997; Trede, 2000). Expert clinical decision making draws upon a well-structured knowledge base, experiential knowledge and procedural knowledge. These findings certainly accord with student recollections from the clinical world in which students express surprise at the extent to which busy practitioners rely upon experiential and personal knowledge rather than the type of knowledge often valued in the university.

These findings mean that educators must not only facilitate the development of student's intellectual ability to "focus on relevant knowledge that is meaningful" (Trede, 2000) but that educators must also pay attention to the process whereby novice practitioners develop the necessary pattern recognition skills.

Certainly, since the seminal work of Barrows and Tamblyn (1980), there is an increasing realisation that the possession of facts and theories gained during the undergraduate years by a process of memorisation will not necessarily translate into informed clinical decision-making. Thus modern approaches to health professional and medical education utilise a variety of educational strategies to ensure that discipline-based knowledge is appropriately contextualised to the practice setting (Coles, 1991). One such strategy is problem-based learning, or PBL. Unlike the classic medical model of professional education PBL sets out to create a learner-centred context in which students come together with their facilitator to share in a process of constructing knowledge and developing understanding.

The third reason for adopting case-oriented learning in radiography instead of using a standard PBL approach is bound up in its assumptions regarding professional practice. For instance, can it be said that all professional practice is concerned with solving problems? In general radiography for instance, practitioners are involved in a process of selecting and implementing an imaging protocol that will deliver the lowest dose to the patient. In arriving at an appropriate clinical decision, practitioners need a sound knowledge of radiation physics, the science of imaging using film or other appropriate media/detectors, the concepts of exposure factors and image quality, gross anatomy and patho-physiology. Far from solving a clinical problem, the professional challenge in this case is for the radiographer to arrive at the best clinical decision through a rigorous evaluation of the research evidence concerning patient dose limitation.

At a more fundamental level, Bawden (1991) argues that the conceptualisation of professional practice, as a series of problems for which solutions can be found, "reduces complex situations in ways which are themselves problematic". Human problems are always going to be related to a larger set of experiences and "contextual conditions" (Margetson, 1991). Therefore, students need to be given "problems" that go beyond a mere exercise in cognitive thinking. They need problems which encourage them at the same time to think about the wider social context in which, and from which, "problems" arise (Drinan, 1991), otherwise PBL can itself "de-contextualise" the learning process (Margetson, 1991). Unlike PBL, a case-oriented approach allows greater flexibility for the creation of real clinical cases that can assist students appreciate the constructive nature of practical knowledge and the key role played by personal knowledge and past experience in the delivery of professional services.

Finally, the adoption of a case-oriented approach to learning radiography gives educators the opportunity to construct cases that facilitate the development of evidence-based practice in radiography. It is expected that the experience gained using SOLAR will directly impact upon the clinical-decision making abilities of students during their clinical rotations and enable them to identify a range of personal and professional issues associated with the practice of radiography. Because SOLAR arises from the challenges and concerns of the professional world, its underlying concept can be extended across all health professions, indeed any professional discipline.

OVERVIEW OF THE SOLAR PROGRAM

When a student runs SOLAR they are presented with a browser environment written in Visual Basic (see Figure 1). This browser allows students to select scenarios, or cases, that are accessed through an XML database. A given scenario is comprised of a small number of HTML pages that as well as text may include images, video or sound clips. After viewing the available information, the student CAP can be submitted using a text box or by submitting a file, or files, of any chosen format. The program also allows users to access a student log so they are able to keep a check on what they have submitted. All the SOLAR scenario data is configured to be placed on the file server of a networked system of computers. The SAVE and PRINT actions occur on the student's PC, while the submitted CAPs are automatically saved to the file server and are only accessible to the supervisor/lecturer for assessment purposes.

The SOLAR program operates in one of three modes selected by the student. The first is the Browser-Mode, and in this mode a student may select a scenario by clicking on the required code on the tree structure, or by typing the code directly into a text box. Provision has been made so that only a very limited set of scenarios can be accessed in this mode in order to reserve the remainder of scenarios for the other two modes (see later). Once the scenario is selected the student is able to access all the information for that scenario; general scenario/case description, the medical request form, professional issues to be specifically addressed, relevant images or other forms of graphics, audio and/or video clips etc. and other suggested sources of information. Any of these pages/screens can be printed and retained by the student. The student also has immediate access to the expert CAP/report so they are able to see what a correct and complete clinical action plan may look like. The Browser-Mode is aimed at student familiarisation of SOLAR.

Figure 1 shows a typical display, where the tree structure that allows scenario selection is on the left of the screen, the various browsing controls are at the top, and the remainder of the screen is devoted to part of the chosen scenario information.

The other two modes are the Class-Mode and the Exam-Mode. They are essentially identical in that to use SOLAR in these modes the student must register using their name, student ID and password. In these two modes the remaining scenarios are accessible. The main difference now is that the student CAP eventually has to be submitted (to the supervisor or lecturer), and the student only gets one chance to do this. Students can save and load and work on their CAP, but once submitted, the student CAP is lodged for assessment and cannot be altered. Directly after the student CAP is submitted, the student then, and only then, can access the expert CAP.

The idea behind the Class-Mode is that the student (or more usually a small team of 3-4 students) would be given a specific scenario code, asked to submit a CAP by some date, and then asked to present, in a 15 to 20 minutes tutorial session, a discussion of what they submitted and compare it to the expert CAP. They would then be assessed on the original CAP they submitted, their presentation and discussion of the scenario, and a comparison of their CAP with that provided by the expert. Used in this mode, particularly, SOLAR has the potential to facilitate the development of students' communication and inter-personal skills.

In Exam-Mode the student works individually and has to submit their CAP within a specified time for assessment. Exam-mode scenarios are only available on a specified date included in the database.

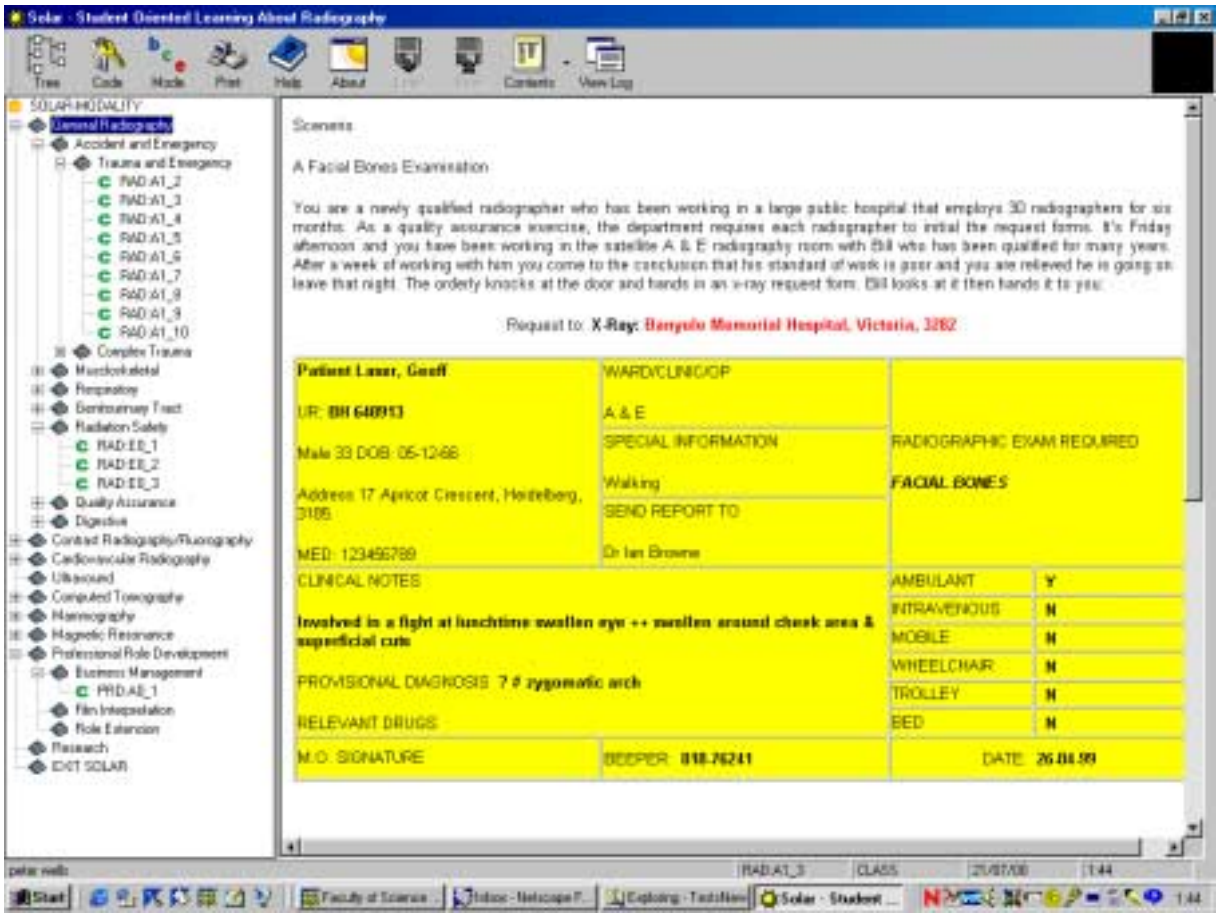

Figure 1: Typical example of a SOLAR screen. The tree structure on the left can be hidden to maximise the scenario display area. Some scenario codes can be seen on the partially exploded tree, and the letter "**c**" in front of each code indicates the SOLAR program is being used in Class-Mode in this example.

THE RADIOGRAPHY SCENARIOS

The scenario are designed about the tree structure and given a unique code. All codes start with 3 letters identifying the modality or topic from the stem of the tree. The codes cover the modalities/topics of General Radiography (RAD), Contrast Radiography/Fluorography (CRF), Cardiovascular Radiography (CAR), Ultrasound (ULS), Computed Tomography (CAT), Mammography (MAM), Magnetic Resonance (MRI), Professional Role Development (PRD) and Research (RES). From this the tree structure branches extend to include scenarios and cases in other related topics. At any branch, or sub-branch level there may well be more than one scenario, and these can be added and removed without difficulty by the teaching staff. An example of a specific scenario code seen in Figure 1 is RAD:A1_6, and might contain the following typical HTML files: Scenario Description, Professional Issues, Medical Request, Image(s), Resources, Expert CAP.

Inclusion of audio and video clips is also possible. The actual labels/headings given to these files are arbitrary, and are decided upon by the scenario/case writer. These headings appear on the Contents menu bar item once a scenario is selected. In addition, the student CAP file, essentially a blank screen with provision for text or other file type input, is also available.

The SOLAR scenarios and cases seek to provide a context in which the student can realistically undertake study aimed at facilitating their skills in dealing with the many conflicting demands of professional practice. Experts may not only be practicing radiographers; SOLAR scenarios have also been written by lecturers in the Radiography & Medical Imaging course and used to assist students appreciate the relevance of academic knowledge to the construction of strategies aimed at resolving a variety of clinical challenges. In any professional context, the problems are often ill defined, may present conflicting demands (for example, technical competence, ethical issues, and interactions with other health professionals), or arise from a range of possible situations. Figure 2 depicts the current types of SOLAR scenarios used, and a more complete description of these scenario types follows.

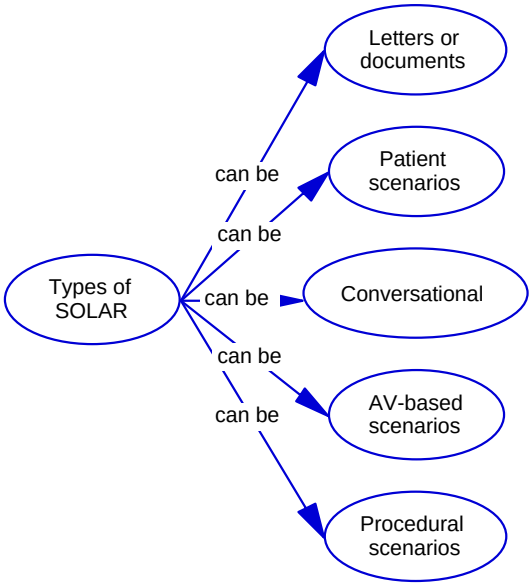

Figure 2: Types of SOLAR scenarios.

Letters or Documents are of the 'please explain' variety. A typical style might be a letter from a surgeon indicating an inadequate radiological assessment, another from a regulatory body for the upkeep of equipment and safety standards. These letters result in the development of a CAP that requires students to assume the role of a senior radiographer and devise, for example, a tutorial to improve the knowledge base of the general radiographers.

Patient Scenarios contain exemplars of everyday patient presentations including some of the more problematic groups, accident cases, children and aged patients, and the disabled. These scenarios mainly address issues related to professional ethics and radiographic practice.

Conversations are one of the most potentially variable of the scenarios types. Conversations are used to 'set the scene' for radiographic examination or for a situation needing further elucidation. They may include conversations between radiographers, or other health professionals. These scenarios may be casual (an informal conversation around the lunch-table, or formal (involving possibly conflicting verbal instructions from a surgeon or radiologist).

Audio-Visual Scenarios are aimed at eliciting responses to radiological images (judgements and, in the cases of poor radiographs or images, suggestions on how to overcome the problem), or a video of particular procedural aspects of radiography.

Procedural Scenarios focus on radiographic or radiological contrast procedures, from simple to complex, and may begin with the presentation to the students of a series of radiographs.

As well as conforming to the types identified in Figure 2, each scenario or case is designed to address a range of possible professional issues. Within radiographic practise 5 potential elements have been identified for each scenario, although clearly not every SOLAR scenario requires students to address all five elements.

1. **Communication and ethical issues such as those involving a range of actors**
- patient
- parent or guardian
- carer (disabled)
- other health professionals (medical practitioners, nurses, physiotherapists, chiropractors)

2. **Patient care issues including**
- medico-legal issues (pregnancy, allergies, actual request versus clinical observations)
- patient history
- explaining the procedure to the patient
- pre- and post-examination patient care
- confidentiality and ethics

3. **Imaging and methods issues including**
- matching projections to clinical history
- dose reduction strategies
- equipment including digital techniques and processing
- selection of exposure techniques
- best practice positioning strategies (for example, in paediatrics)

4. **Radiographic interpretation issues such as**
- legal requirements
- image quality
- artefacts
- clinical acceptability of the radiograph
- correlation between patient presentation and request form
- radiographic anatomy and pathology

5. **Radiographic technology concerns including**
- an observed problem, malfunction and solution
- quality assurance, procedures, data collection and interpretation
- comparative review of technological advances

At present SOLAR comprises about 85 scenarios mainly in the area of General Radiography. The intention is to add to these scenarios at the rate of about 40-50 per year in the various branches of the SOLAR tree as required by the students during their 4 year course.

THE IMPACT OF SOLAR UPON STUDENT LEARNING OUTCOMES

The 4-year Bachelor of Radiography & Medical imaging degree course was introduced in 1998. At present there are approximately 36 students in each of the first 3 years of the course,

with the fourth year to commence in 2001. During the four years the students each complete approximately 2500 hours of clinical practice. In keeping with the view that content knowledge is crucial to effective practice, the first year of the course provides students with the opportunity to develop appropriate foundational discipline-based knowledge related to radiography. The SOLAR program is introduced to students in semester one of second year.

In the first semester of year 2, students are provided with two weeks of background lectures designed to start them thinking more broadly about the kinds of issues related to radiographic practice. Following five weeks of clinical studies students return to the university and work for six weeks with the SOLAR program. Besides completing individual cases, the student cohort is divided into three large groups of around 12 students, which are then further subdivided into four smaller groups of 3 students. It is in these small groups that students work on more complex SOLAR cases. Finally, the large student groups select a major investigative case from the Professional Role Development section of the SOLAR tree and report their findings to their peers. At the end of semester one the second year students were surveyed to ascertain the degree to which the aims and objectives outlined above had been achieved through the use of the SOLAR program. Students were asked to respond to the statements shown in Table 1.

Department of Radiography, Monash University

Please indicate your agreement or disagreement with the following statements to help us to assess SOLAR (Student Oriented Learning About Radiography) at this time. Note that this is an anonymous survey.

	Strongly AGREE	**AGREE**	**UNDECIDED**	**DISAGREE**	**Strongly DISAGREE**
1 The cases I have seen represent real-life scenarios					
2 SOLAR has allowed me to develop my decision-making skills in radiography					
3 Comparing my Clinical Action Plan (CAP) with that of an expert has been helpful					
4 SOLAR has helped me to develop evidence-based clinical reasoning skills					
5 SOLAR provides access to academic and professional papers					
6 SOLAR lets me discuss my results with my peers					
7 SOLAR lets me engage in investigation and research					
8 SOLAR has helped me to develop my problem-solving skills					
9 Overall, I believe that SOLAR is helpful to my studies in radiography					

ANY OTHER COMMENTS

Your time spent in completing this form is gratefully acknowledged.
Dr Marilyn Baird
Head, Department of Radiography & Medical Imaging
May/June 2000

Table 1: Student SOLAR evaluation questionnaire.

RESULTS

In 2000 the second year student cohort was 36, and 35 anonymous questionnaires were completed and returned. For the purposes of reporting the results, the completed questionnaires were numbered from 1 to 35. As the results in Table 2 indicate, none of the students disagreed with any of the stated propositions in the questionnaire. Rather, there was overwhelming support for the propositions put to the students. There was unanimous agreement that SOLAR was helpful to their radiography studies. Students appeared to think carefully about each proposition. By way of example, student 6 strongly agreed with all of the statements, except the first statement where the student simply agreed. However, the same student was undecided about the usefulness of comparing their CAP with that provided by the expert. This equivocation could be directly related to the particular cases the student had completed. This student also indicated at the end of the questionnaire that "SOLAR was an extremely useful way of learning". Student number 34 believes SOLAR is "a good teaching aide, different from lectures, interactive and more interesting!"

Statement	Strongly Agree	Agree	Undecided
1	18	16	1
2	13	19	3
3	14	17	4
4	15	19	1
5	15	17	3
6	18	15	2
7	25	9	1
8	14	17	4
9	15	20	0

Table 2: Summary of SOLAR questionnaire evaluation results.

In the absence of any negativity or disagreement from the students that SOLAR had achieved its aims, it can be concluded that the aims established for SOLAR have been accomplished. Student number 2 made this interesting observation: "The cases were useful - especially if one had covered the topic while on clinical visits. This was good and bad. If you had already done it the case was easier and if you hadn't there was a lot to learn but this was useful". Here we see evidence of a student starting to make those important and crucial links between the clinical practice and the academic world. Rather than seeing each as a separate entity, through the SOLAR program, this student is making a connection between them.

Several students made suggestions for improvements. Two students wanted to see a word limit on the CAPs and another student argued "there should be more emphasis placed on discussion of SOLAR topics with our peers to increase the knowledge of topics obtained". Several students found the time frame for completing the major investigative case too short. These are reasonable comments. The student cohort was provided with three opportunities to present their clinical action plans to their peers, but clearly this needs to be increased. It may be that the schedule was a little too ambitious by including the Professional Role Development project as well as the other SOLAR activities. In 2001 it is planned to remove this project in the first semester at second year level and focus more upon the individual cases and small group cases, along with more debriefing and discussion amongst the students to enhance the interchange of ideas.

CONCLUDING REMARKS

It is far too early to claim that the experience of SOLAR has resulted in the creation of graduates who are self-organised, ethical and critical thinkers with the capacity to implement research findings to their practice. More long-term research into the clinical decision making approaches adopted by Monash graduates will be needed. Nevertheless, the results of the student survey are encouraging. SOLAR has been well received by students. At the same time the program is gaining acceptance amongst our peers. Two other Australian university providers of degree education in radiography and radiation therapy have indicated a strong desire to enter into a partnership with Monash and collaborate on the further development of SOLAR.

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of Roger Hadgraft from CHED at Monash University in constructing the questionnaire. Much of the SOLAR software was written by Neil Fillingham and Nicholas Treweek, and the help of Adrian Ling in sorting out the best way to build SOLAR on the file-server has been invaluable. The development of the SOLAR program was assisted in part by a Monash University 1999 SIF Grant.

REFERENCES

1. Balla, J.I., Biggs, J.B., Gibson, M. and Chang A.M., "The Application of Basic Science Concepts to Clinical Problem-Solving", *Medical Education*, **24**, 137-147, 1990.

2. Barrows, H.S., and Tamblyn, R.M, *Problem-Based Learning: An Approach to Medical Education*, (New York: Springer), 1980.

3. Baird, M.A., *The Preparation for Practice as a Diagnostic Radiographer: The Relationship Between the Practicum and the Profession*, (Unpublished PhD, La Trobe University: Bundora), 1998.

4. Bawden, R., "Towards a Praxis of Situation Improving", in D. Boud and G. Feletti (Eds), *The Challenge of Problem Based Learning*, (London: Kogan Page), 1991.

5. Coles, C. (1991) Is Problem-Based Learning the Only Way?, in: D. Boud and G. Feletti (Eds), *The Challenge of Problem Based Learning*, (London, Kogan Page).

6. Drinan, J., "The Limits of Problem Based Learning"., in D. Boud and G. Feletti (Eds), *The Challenge of Problem Based Learning*, (London: Kogan Page), 1991.

7. Eraut, M., "Developing the Knowledge Base: A Process Perspective on Professional Knowledge", in R. Barnett (Ed) *Learning to Effect*, (Buckingham: SRHE & Open University Press), 1992.

8. Fish, D. and Twinn, S., *Quality Clinical Supervision in the Health Care Professions*, (Oxford: Butterworth-Heinemann), 1997.

9. Heggie, J.C.P., "A Survey of Doses to Patients in a Large Public Hospital Resulting From Common Plain Film Radiographic Procedures", *Australasian Physical & Engineering Sciences in Medicine*, **13**(2), 71-80, 1990.

10. Higgs, J., "Developing Clinical Reasoning Competencies", *Physiotherapy*, **78**(8), 575-581, 1992.

11. Margetson, D., "Why is Problem-Based Learning a Challenge?", in D. Boud and G. Feletti (Eds), *The Challenge of Problem Based Learning*, (London: Kogan Page), 1991.

12. Matthews, I.P. and Rogers, K.D., "Malignancies Induced by Low Dose Ionizing Radiation: Consequences for Diagnostic Radiology", *Radiography*, **50**(594), 277-280, 1984.

13. Matthews, I.P. and Rogers, K.D., "Prevention of Radiogenic Cancers Through Changes in Procedure", *Radiography*, **54**(613), 3-8, 1988.

14. Murphy, D., Jamieson, P. and Webster, L., "What is Flexible Learning?", in *Flexible Learning Guide*, Number 1 (Centre for Higher Education Development, Monash University), 1998.

15. Norman, G.R., "Problem-Solving Skills, Solving Problems and Problem-Based Learning", *Medical Education*, **22**, 279-286, 1988.

16. Rosenberg, W. and Donald, A., "Evidence Based Medicine: An Approach to Clinical Problem-Solving", *British Medical Journal*, **310**, 1122-1126, 1995.

17. Schon, D., *The Reflective Practitioner: How Professionals Think in Action*, (New York: Basic Books), 1983.

18. Trede, F., "The Role of Knowledge and Artistry in Clinical Expertise: A Pilot Study with Rheumatology Physiotherapists", *Focus on Health Professional Education*, **2**(1), 48-57, 2000.

19. van der Vleuten, C.P.M., Dolmans, D.H.J.M. and Scherpbier, A.J.J.A., "The Need for Evidence in Education", *Medical Teacher*, **22**(3), pp. 246-250, 2000.

20. Wells, P., Baird, M. and Fillingham, N., "A Computerised Case-Based Learning and Clinical Decision Making Program in Radiography", *Proceedings of the International Conference on Computer Based Learning in Science*, CBLIS'99, University of Twente, Enschede, The Netherlands, 2–6 July, 1999, paper F4.

AUTHORS

Associate Professor Peter Wells
School of Physics and Materials Engineering
Monash University
PO Box 27
Victoria 3800
Australia
Email: peter.wells@sci.monash.edu.au
Tel: INT+613 9905 3694
Fax: INT+613 9905 3637

and

Dr Marilyn Baird
Department of Radiography & Medical Imaging
Monash University
PO Box 64
Victoria 3800
Australia.
Email: marilyn.baird@med.monash.edu.au
Tel: INT+613 9905 1270
Fax: INT+613 9905 8149