Bryce, D.A., King, N.J., Graebner, C.F. & Myers, J.H. *Evaluation of a Diagnostic Reasoning Program (DxR): Exploring Student Perceptions and Addressing Faculty Concerns.* Journal of Interactive Media in Education, 98 (1) [www-jime.open.ac.uk/98/1]

Published 12 May 1998

ISSN: 1365-893X

Evaluation of a Diagnostic Reasoning Program (DxR): Exploring Student Perceptions and Addressing Faculty Concerns

Deborah A. Bryce*, Nicholas J.C. King, Celia F. Graebner+, J. Hurley Myers++**

Abstract: Clinical reasoning is essentially a problem-solving process, in which medical students must learn to gather and interpret data, generate hypotheses and make decisions. To develop skills in problem-solving it is argued that students need more tools, rather than more answers (Masys, 1989). DxR is a computerised case series, in which students use 'doctor tools' to investigate a patient problem. This report describes a pilot evaluation of DxR in fourth year medicine at the University of Sydney. It addresses faculty concerns regarding the program, explores student perceptions, and looks at the capacity of the program to stimulate and support the development of clinical reasoning skills. It finally discusses possibilities for using DxR to support learning inmedicine.

Keywords: Evaluation, medical education, clinical reasoning

Demonstrations: DxR is distributed by NOVARTIS www.meded.pharma.us.novartis.com, although the DxR cases described in this article are not the same as those listed in the Diagnosis category of their bookshop/website. A Macromedia Director demonstration copy of DxR can be obtained by contacting Tanaya Patel, Project Director, DxR Development Group (tanaya.patel@dxrgroup.com). Alternatively, a demonstration CD, and complimentary catalogue of patient cases and price list can be obtained by calling 800-631-1181 (USA).

Commentaries: All JIME articles are published with links to a commentaries area, which includes part of the article's original review debate. Readers are invited to make use of this resource, and to add their own commentaries. The authors, reviewers, and anyone else who has 'subscribed' to this article via the website will receive email copies of your postings.

* *Department of Anatomy and Histology, F13, University of Sydney, N.S.W. 2006, Australia*
Email: debryc@anatomy.usyd.edu.au
* *Department of Pathology, University of Sydney, N.S.W. 2006, Australia*
+ *Centre for the Study of Networked Learning, Division of Adult Continuing Education, University of Sheffield, 196-198 West Street, Sheffield, S1 4ET, U.K.*
Email: C.Graebner@sheffield.ac.uk
++ *Department of Physiology, School of Medicine, Southern Illinios University, Carbondale, IL 62901, U.S.A.*

1. Introduction

> *"Effective learning is concerned with learners attempting to establish more and more complex networks of knowledge rather than storing information as discrete and separate entities. High quality learning, the basis of problem solving and professional thinking, results from 'pulling things together', that is by constantly structuring and restructuring what we know into a more and more elaborate knowledge, which is the basis for problem solving and professional thinking." (Coles and Holm, 1993)*

If we define effective learning as described above, how do we encourage (and support) this process? The answer lies in providing learners with the opportunity to handle knowledge, and to elaborate knowledge in a relevant context. If an integrated knowledge network is desired, students need to practise integrating knowledge. If we want to encourage efficient and effective problem solving, we also need to provide feedback.

The DxR program appeared to have the qualities needed to support this learning process in medical education. It provides students with an initial problem, allows them to use relevant tools of investigation to gather, interpret and 'pull together' information, and provides feedback. A pilot evaluation was carried out to determine students' response to the program, and to look at how it could be used to facilitate learning in Year Four medicine. In addition, the evaluation needed to address a number of faculty concerns regarding the program (see 4.4, 7.3.2).

1.1 Background Information on DxR

DxR is a commercially available product, produced in the United States (tanaya.patel@dxrgroup.com), in Hypercard for the Macintosh and in Toolbook for the PC. It is a simulated patient encounter that provides the user with tools to gather data in order to diagnose and optionally treat a patient. Students are required to reiteratively state the patient problem, generate hypotheses and interpret information (e.g., X-rays, breath sounds). Unlike systems of teaching diagnostic reasoning that use case vignettes, and summarised patient histories (see Barrows, 1990), students are free to follow their own path of inquiry through the patient investigation, and may select from a database of history questions (260 questions, 20 categories), physical examinations (425 exams) and laboratory tests (440 tests). At the end of each case (after diagnosis of the problem) computer feedback is given on the students' investigation (a comparison to a case writer's model investigation), which includes information on the cost of lab tests to the patient.

Additional features of the program include an editable "NOTE" section into which students can paste (and edit) patient data, a "CONSULTANT" feature which gives an expert's interpretation but only after students have made their own interpretations and a 'LIBRARY' icon which may link the learner to resources (*e.g.*, ECG teaching software, Medline search facilities)

A typical path through the program is represented by moving through Figures 1 to 10.

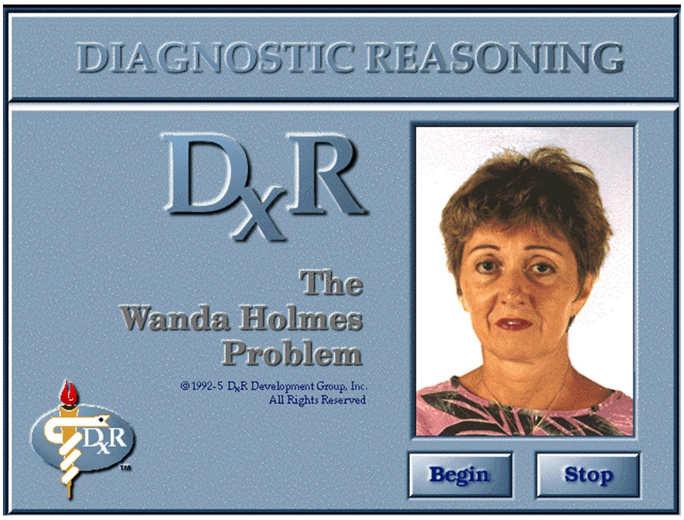

Figure 1. *Opening screen: patient name and image.*

Figure 2. *Brief statement of patient problem and options to interview, examine or order tests on the patient, or exit the program.*

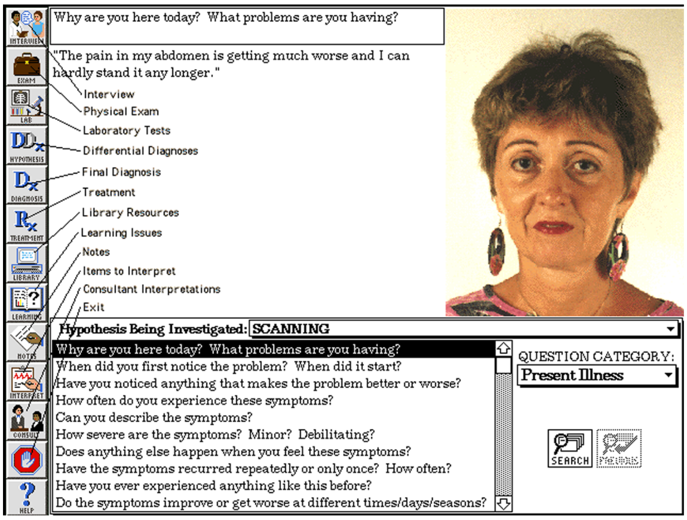

Figure 3. *Present Illness screen of Patient Interview*

Note that the Present Illness category of questions is in the form of complete questions (in contrast to the other question categories, see Figure 5.)

Icons along the left margin of the screen remain consistent throughout the history, examination and lab interfaces. Patient data can be stored in NOTES to avoid repeatedly requesting an investigation if results are forgotten. Items that students have not immediately interpreted are stored in the INTERPRET section. The student is not permitted to diagnose the patient problem until all items stored in this section have been interpreted. An expert interpretation or CONSULT is available, but only after students have made their own interpretation. The LEARNING icon is used by students working in a problem-based learning mode, whereby students start a case, identify (and record) areas they need to learn about, leave the program, then later return to complete the case. Tools are available to link resources to a case. Once linked, these can be accessed via the LIBRARY icon.

The interface in Figure 4 appears when students move from the Present Illness to another question category. Before being allowed into the next question category, they must first state the patient problem and generate a number of differential diagnoses based on the information gathered in the Present Illness. If they are not ready to do this they may return to the Present Illness category.

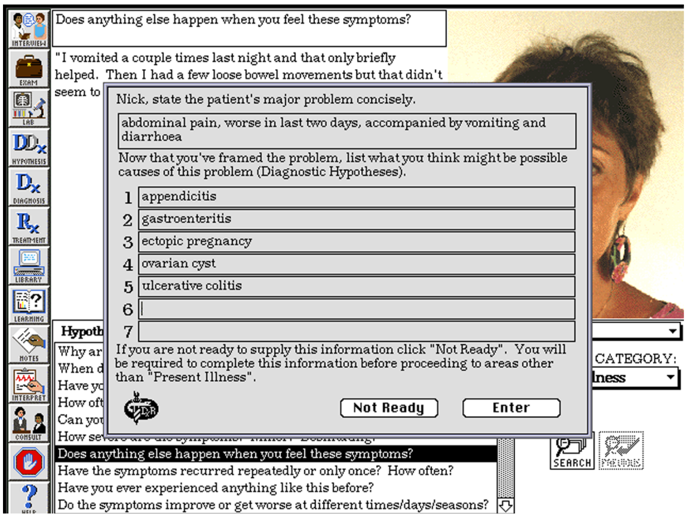

Figure 4. *Requirement to state the patient problem and generate hypotheses before progressing.*

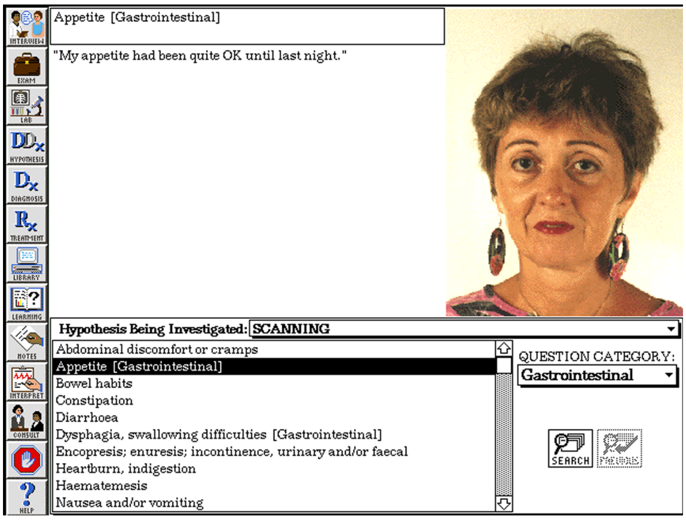

Figure 5. *Gastrointestinal category of Patient Interview.*

Note that the items in all question categories other than Present Illness are abbreviated and not in the form of full questions.

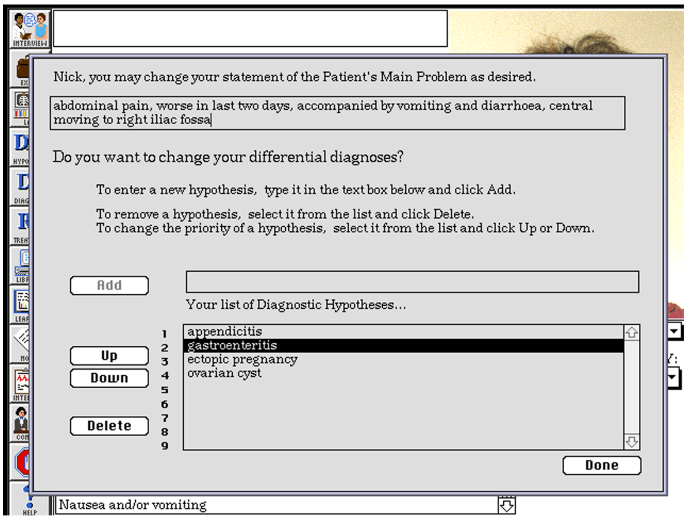

Figure 6. *Reminder to refine and re-rank hypotheses (at end of interview, and physical examination).*

This interface (Figure 6) encourages students to actively reflect on their hypotheses (add, delete, re-rank), in relation to the information they have gathered from the previous section, and prior to moving on to a new section of the investigation.

Figure 7. *Physical Examination interface showing doctor tools and four body image options.*

Doctor tools in Figure 7 include options like thermometer, stopwatch (pulse rate, respiratory rate), stethoscope, and ophthalmoscope. The student clicks on a tool, then places it over a body part. Placing the stethoscope over the appropriate body part will give an auditory output that will require interpretation (e.g., heart sounds). Images (*e.g.*, fundus of the eye) also require interpretation. "Other Exams" includes a range of neurological and other tests, some of which may be linked to a QuickTime video clip.

In Figure 8, the INFO button allows students to get information (including cost) on a test prior to ordering. The N icon gives normal ranges for comparison to patient results. Images such as ECG, X-ray and CT scans require interpretation, and some tests (controlled by the teacher) when ordered will give a dialogue box asking for a rationale for ordering the test.

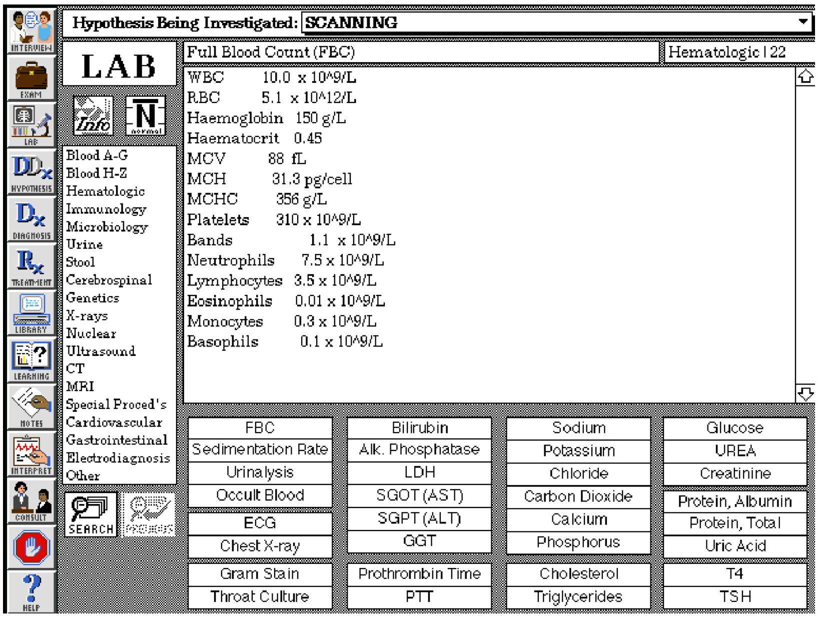

Figure 8. *Laboratory interface showing common icons in the lower part of the screen, and broad categories listed on left.*

When students are ready to diagnose the patient problem they click on the Dx icon, and select the diagnosis from their list of hypotheses (Figure 9). A second dialogue box (Figure 10) then asks for a more detailed explanation of the diagnosis. Teachers may wish to provide students with a guideline on how to record information in this section.

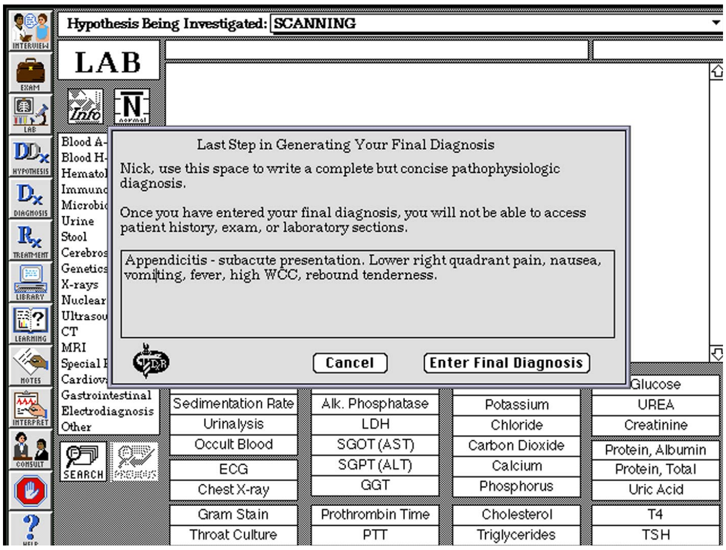

Figure 9. *Request to expand on the diagnosis (previously selected from the hypothesis list).*

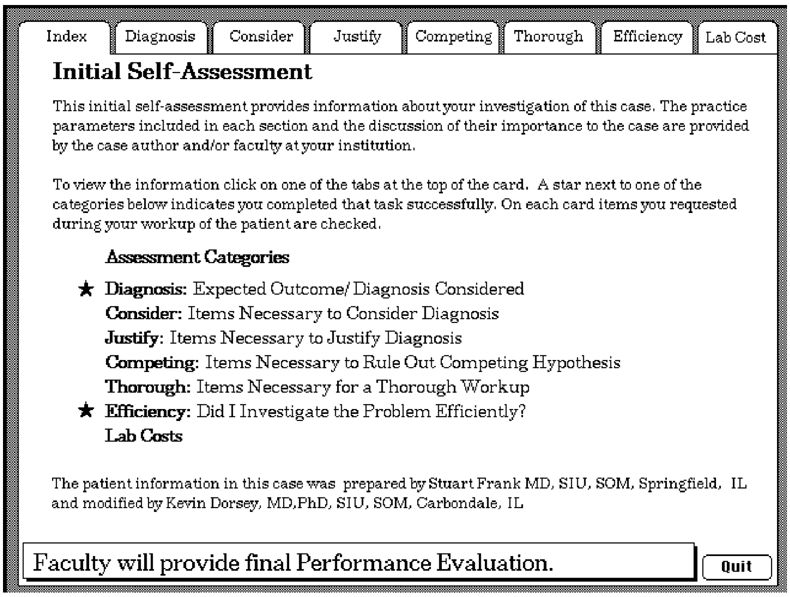

Figure 10. *Computer feedback on the patient problem.*

Clicking on the relevant tag gives the diagnosis and lists of the items considered important to request, with associated explanatory text. “Lab Cost” gives the lab items ordered, their cost and the total cost of the investigation. A star beside efficiency indicates the investigation was carried out within the set efficiency limits.

DxR also provides tools for teachers to customise cases and view student records. It is possible to alter content, modify the case writer’s evaluation criteria, control parameters, for example, the efficiency limits, and ‘tag’ assessment questions to investigation items. Teachers may also create their own cases. The ‘trail of logic’ of users is tracked and recorded by the program, and can be organised in a form that enables teachers to view either an individual’s path through a case or review summaries of a cohort’s performance.

The program design is consistent with sound learning principles. It provides a relevant context for learning, is problem-based, requires the user to actively handle and synthesise information, and provides timely feedback. Designing software on an understanding of learning theory, however, does not automatically guarantee an effective teaching strategy (Laurillard, 1993; Ramsden, 1992) and evaluation of the software in the context of use is critical to determining its level of effectiveness and the type of learning it promotes.

2. Evaluation of DxR

The DxR program was evaluated in Year Four medicine at The University of Sydney. These students are in their first full-time year of clinical training in a hospital setting and are developing the skills of history taking, physical examination, and clinical reasoning.

Although the emphasis of the evaluation was qualitative, a quasi-experimental design was used as a preliminary gauge of learning outcomes. A total of one hundred and ten students at two teaching hospitals were divided into a study (DxR cases) and control (no DxR cases) group. This was done by randomly dividing each tutorial group in half; both study and control groups were therefore exposed to the same teaching. Students worked through cases in groups of between two and four. Eight cases were presented, one case per week. Participation in the pilot study was not compulsory.

A triangulation of data gathering methods (qualitative and quantitative) was used.

1. Group observations: to provide information on navigational issues and level of engagement with patient cases.

2. Focus groups: to gauge student reactions to the program, their perceptions, and to generate issues for inclusion in a questionnaire.

3. A questionnaire: to quantify student responses to issues that arose out of observations and focus group interviews.

4. A written examination: to measure learning outcomes.

5. Case feedback sheets (left beside the computer): to identify inaccuracies / inconsistencies in case content.

Observations. Six groups of students were observed using the program. A record sheet, organised by user interface (*e.g.*, interview , exam) was used to note navigational problems. Icons not used by students were recorded by crosses on a check list. Notes were also made by the observer at the end of each session, on the impressions of students' level of engagement and general actions. (*e.g.*, "they were all actively involved, discussed the differential diagnosis, exams and tests, and were concerned they stayed within the efficiency limits" and "lots of tests and repeats, because couldn't remember [the patient responses]", "did not re-order/add/delete differential diagnoses"). Informal discussions with students after these sessions gave the observer an opportunity to discuss the program, discuss issues the students wished to raise, and clarify some of the observations (see 4.1, 4.2, 4.3).

Focus groups. A focus group (semi-structured) of 12 students each, was conducted at the two hospitals. The interviews (approximately 50 minutes duration) were taped, transcribed, summarised and the summary given to a student representative, to review and comment on its accuracy and completeness. Items discussed in the focus group included: perceptions of the value of the program as a learning tool, perceptions of the "potted history" and it's effect on their learning, how the program compared to real patient contact, what they liked and didn't like about the program, the advantages and disadvantages of working in a group, how they would prefer to use the program, and why some students did not use the program.

Questionnaire. The questionnaire consisted of 50 questions (Likert scale 1-5) with an open response section (see Appendix). It looked at students' perceptions of the program, and how they wished to use it.

Written Examination. The written examination was designed to assess clinical content related to the DxR cases. It consisted of thirty multiple choice questions that tested content embedded in a clinical context. The effectiveness with which students work through a clinical problem strongly correlates with their knowledge base (Newble, van der Vleuten and Norman, 1995). Therefore embedding content within a clinical context, so that a question cannot be answered without the context, is a recommended approach to gauging clinical reasoning skills of students at this level in their medical training (Newble, van der Vleuten and Norman, 1995). Fifteen questions related to DxR and fifteen questions unrelated to DxR cases were included, and the outcomes of study and control groups compared.

3. Findings

3.1 Preliminary Statement

The findings of the pilot study need to be interpreted in the context of factors that can negatively affect participation, and motivation.

- Firstly, participation was voluntary. If a program is not compulsory, does not contribute to their assessment and if work loads are high, students commonly disregard it.
- Secondly, the students were given no specific training in how to use the program, however they were given a DxR User Manual.
- Thirdly, in the first two cases encountered, students were given a summarised patient history ("potted" history), rather than having the freedom to select questions from a comprehensive question bank. This was to answer one of the concerns of faculty (see 7.3.2).
- Fourthly, the cases were randomised and not specifically sequenced to the specialty subjects being studied. The second case was reported to be very difficult by many students, and caused some disillusionment in some students.
- Fifthly, students were asked to work through the program in predetermined groups. Many reported finding it difficult to organise a meeting time convenient to all members of the group.

3.2 Participation

Of the seventeen groups, fifteen worked though the first case, thirteen the second case, ten the third, eight for cases four to six, and five and four respectively for the last two cases (see Table 1.). Forty seven percent of the study group students stayed with the study for 75% of the study. In the last two cases i.e., the 7th and 8th cases, the participation rate fell to 29% and 23%, respectively. The participation reflected better than expected support of the program, particularly given that it was voluntary, additional to their heavy workload, and at times difficult. This was a powerful indicator to the evaluators that the program was valued highly enough by the students to surmount the problems listed above, and keep them interested and challenged.

	Total No. Groups	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
No. Groups	17	15	13	10	8	8	8	5	4

Table 1. *Participation rates (2-4 students per group)*

The principle reason put forward by students for not participating at all in the study was that the program was not compulsory and therefore not a priority for them. These students preferred to spend their time seeing patients in the wards, or on other 'scheduled' activities. Reasons for students stopping the program were that the second case was more difficult than they expected, the potted history frustrated them and reduced their interest, and groups were difficult to organise.

4. Perceptions of DxR

4.1 Ease of Use.

Fifty four percent of students (31 students) in the study group completed the questionnaire. Of these, sixty eight percent felt (that with no training) the program was easy to navigate, twenty six percent disagreed (Q3). Observations indicated that students moved intuitively through the program. The only noted difficulty with the interface (observation, discussion with students) were:

- the function of a few buttons that were unclear;
- difficulty finding some questions and tests;
- some could not re-enter the program when returning to complete a case due to incorrect entering of identity.

It was also noted that some aspects of the interface (e.g., notes section) were under-utilised, probably due to lack of training in the use of the interface. Ninety percent of students felt that the program would better help them learn if an initial training session was provided (Q40).

4.2 Likes.

Seventy one percent of questionnaire respondents enjoyed using the program (Q32). This was considered high given the barriers to motivation (see 3.1). Students said the program was interesting, fun, non-stressful, yet forced them to think. They appreciated the opportunity to practice gathering information and piecing together a patient problem, and liked being able to work through a patient problem from beginning to end. They also appreciated the feedback on their performance. Focus group responses included:

> *"[It was] a challenge with an answer", "you knew there was a diagnosis at the end and if you worked through you could get to it", "It gives you a real sense of achievement because... you did the whole examination, ordered investigations and came up with a diagnosis at the end. I really enjoyed that."*

4.3 Dislikes.

Students were frustrated by having to interpret each heart and lung sound individually. They also had difficulty at times, searching for some items in the data base. This was complicated by differences in terminology. The cases were written in the United States, and some American tests differed in name from their Australian counterparts. In addition, the standard units in America differ from Australian units (e.g., temperature in degrees Fahrenheit versus Celsius).

Students did not like the "potted" history in the first two cases. After the second case, they asked that the full bank of questions be made available, because the potted history did not allow them to *"narrow down to the real cause"* and *"if you can ask questions in the history you start to piece it all together"*. Because of the unanimity of this response, the full bank of questions was made available for the remainder of the cases.

Many students reported being frustrated by the second case, because it was difficult and they had not covered this topic to date. Although it proved frustrating to some students, to others it was an exciting stimulus to learn (discussions between observer and students). Interestingly, some students reported encountering a similar case, in a lecture a number of months later. They said that because they had struggled to solve the problem with the computer patient, when they came across the case in a later lecture it impacted powerfully in their minds. As a consequence, they felt sure they would not forget the lesson learned (to consider developmental anomalies in paediatric renal presentations). The general feeling of students, however, was that cases on topics they had not yet covered added too much to their already heavy workload.

4.4 DxR Patients vs Real Patients.

Clinical educators were interested in how students perceived the DxR patient as opposed to real patients. There was a concern that the introduction of DxR would reduce the value placed on seeing real patients in the wards. The students, however, highly valued real patient interaction, particularly for developing skills in history taking and physical examination, and learning to think on the spot. They felt the program could not replace real patient contact (83%) (Q10) but should be used as an adjunct (84%) to real patient contact (Q11).

> *"I don't think you can compare .. I mean.. seeing, talking to a patient, examining them yourself is quite different than clicking a button on a computer. You can gauge their reactions to your examination, even their reaction as you're talking to them. I mean, that gives you an idea of how they're feeling and how bad things are... And when you're examining them, you know, if things really hurt here. It's quite different I think. The computer gives you an idea about what you should be doing, and the general sort of steps you should take, but it's quite different when you get an actual patient, because their reactions are quite different."*

The advantages of simulated patient cases for students (focus group) were that :

- the cases gave them greater exposure to patient problems;
- they could follow all the way through on a patient, including ordering lab tests and suggesting treatment, which was not otherwise possible with real patients;
- computer patients were always accessible, unlike real patients;
- they could look up books and discuss the case while working through the problem, which they couldn't do in a real patient situation;
- it was easier to think clearly with a computer case (they had difficulty thinking clearly while 'on the spot' with a real patient);
- the computer cases were not stressful, whereas real patient interaction could be highly stressful; if a mistake was made, they did not feel embarrassed or intimidated with a computer;
- they could try things on a computer patient they could not try on a real patient.

5. Learning From Cases

Group observations and focus group feedback indicated that the students were learning from the program. In addition, students felt the program was an effective educational tool if used appropriately (87%)(Q39). An important type of learning in medicine is learning to think through a clinical problem (clinical reasoning).

5.1 Learning Clinical Reasoning Skills

The term "clinical reasoning" is defined as the thinking and decision-making processes required for an appropriate understanding of situations as the basis for optimal clinical intervention (Higgs and Jones, 1995). It comprises three elements: a context-relevant knowledge base, cognitive skills (eg. analysis and synthesis), and metacognitive skills. Each element will be considered in turn with respect to learning from DxR.

1. Development of a Context-Relevant Knowledge Base

Students report that DxR helped test their (existing) knowledge (90%)(Q15) and identify gaps in their knowledge (90%)(Q16). Sixty eight percent of students said that identification of gaps in their knowledge triggered them to return to clarify the area (Q34).

It helps to:

> *"gauge how much we don't know, what sort of skills we have, or how to think about what we're doing". "It helps to reinforce your knowledge." "It facilitates understanding."*

In the development of their knowledge base students discussed cases and looked up texts while working at the computer. Some left the program to access resources, particularly when working through the difficult, second case.

2. Cognition

Higher level aspects of the thinking process (e.g., synthesis, analysis, decision making) are promoted by the program design, which requires students to generate their own path through the investigation, interpret findings, generate differential diagnoses, and explain decisions (e.g., why a test was ordered). Students reported DxR helped them to practise reasoning through a patient case (90%) (Q19) and helped to sharpen their thinking processes (71%) (Q14). The program 'forced' them to think, but the process was less stressful than a real patient interaction.

> *"[The program] helps you learn how you should be thinking when you're with a real patient. "I think of it as a program that sharpens your thinking process..." "I think [it helps] you gain confidence on your power to think."*

3. Metacognition

Metacognition is the awareness and monitoring of one's thinking processes. The development of metacognition was supported in two ways. Firstly, through the provision of computer feedback on performance. Students evaluated their performance against an expert, and were able to compare the expert's reasoning (e.g., differential diagnoses considered, tests performed) to their own. In other words they were using the feedback to monitor their own thinking. Many students, however, would have liked more feedback from the computer (*e.g.*, lists of provisional diagnoses) (see discussion, 7.4.4, 7.4.5). Secondly, the group interaction supported metacognitive processes in that students were asked to explain their reasoning to others in the group, particularly when someone disagreed with them.

> *"I really liked doing it in a group because you had to justify why you thought it was... like if you wanted to put something on a provisional diagnosis list and someone disagreed with you, you'd have real arguments about, you know, why you thought it should be on and why they didn't think it should, and that was really good, because it really made you justify your line of thought."*

The self-paced, non-threatening, flexible nature of the program allowed the time and space for metacognition to occur.

5.2 Learning in a group

Observation of students working in groups, clearly showed them to be engaged in the cases. The groups discussed their hypotheses, which items to request and sought clarification, for example, when trying to interpret a test. Some groups worked with text books and looked up information while discussing the case. A ten minute debate was observed with one group over whether a test should be ordered, based on cost, invasiveness and the relative value of the information that would be obtained.

Students commented that working in groups helped them to learn because of the combined knowledge of the group; they liked being able to draw on the knowledge of others. Some also thought group work was faster for this reason. The evaluator would question the second assumption however, after sitting in on a number of lengthy group discussions. Some students also commented that they liked group work because it challenged them to justify their thoughts to other group members.

The questionnaire results on group work were mixed, however. Sixty seven percent of students felt that groups were helpful for learning (Q27), but 26% felt they were not helpful (Q28).

Focus group interviews and informal discussion revealed difficulty arranging a convenient time for all group members to meet. In addition, some groups had members who did not contribute. The groups in this trial were selected randomly by the evaluators, but students were interested in groups of their own choosing (71%)(Q49) and were even more keen to work on cases on their own (88%) (Q48).

5.3 Quantitative outcomes of learning

Learning was also examined from a quantitative view point. Strict study-control group studies are almost (Lyon, et al., 1997) impossible in an educational setting (Clark, 1991). However, despite the "black box" variables of this type of design, it was our aim to obtain a quantitative (as well as qualitative) indication of learning. The outcomes (Table 2) revealed no significant difference between the study and control groups (see 7.2.1).

Case-related questions		Non case-related questions	
Study group	74% correct	Study group	74.5% correct
Control group	70% correct	Control group	73% correct

Table 2: *Outcome of quantitative analysis of the study and control groups*

6. Unexpected Outcomes

A number of unexpected outcomes came out of observations and discussion with students.

1. Cost awareness.

Students became very aware of cost when ordering lab tests (87%)(Q25) and altered their test ordering behaviour accordingly. Costly tests were avoided by some if they were unsure of the benefit that would be gained.

2. Empathy with a computerised patient.

Empathising with the patient did not occur with all groups. However, some students reported they were reluctant to perform invasive procedures, when unsure whether a test was necessary (e.g., muscle biopsy). This surprised them in hindsight as they knew the patient was not 'real'.

3. Desired mode of case presentation.

Students in the focus group at one hospital wanted cases to be presented by problem area (e.g., heart problem), rather than by symptom (*e.g.*, chest pain) because that was how they encountered patients in the wards, for example, when in the cardiology ward, they knew they would see patients with heart problems. This response was unexpected, however, the argument was rational and consistent with the context of their learning in the wards. Interestingly, however, when the same question was posed to the students at the second hospital, the response was quite different. This group of students argued that knowing the problem area (*e.g.*, heart) beforehand was detrimental to their learning, and would lead them to rule out a number of important differential diagnoses that should be considered and followed up in a patient investigation. When clinicians were informed of this difference in outlook, it did not surprise them. It seems that these differences reflect different hospital cultures.

7. Discussion

7.1 Value of the program to students

The greatest value of the program to students was in three areas, the independence afforded by a computer program, the completeness of the patient interaction, and the practice at reasoning through a clinical case.

7.1.1 Greater Independence

One important advantage of DxR cases for students was that it gave them greater independence in their learning. The independence took two principle forms:

Clinical problem solving was not tutor- or patient-dependent

Students are usually dependent on the presence of a patient and/or tutor to work through a clinical case. However, real patients are not always available when students want to see them, and when working with patients in tutorials, students may not get an opportunity to take a full history and/or perform a full examination in each session.

Patient access can be a problem for students. Patients may be in hospital for a very limited stay, may be too sick, or otherwise occupied when students seek them out. Alternatively, patients may have reached saturation point with student attention. All of these factors, can lead to frustration. Some students reported a constant struggle, finding a balance between the invaluable experience of real patient interaction and text book learning. On the wards, it can be a gamble; they may learn a lot, or alternatively they may feel they have wasted a great deal of time. With a text book they felt they were guaranteed to learn but it was no substitute for the richness of real patient contact.

The advantage of the computer cases was their availability. If they arranged to work through a case at a given time, they could, and did not have to suffer the vagaries of real life situations. They also knew that when they worked through a case they would get an answer at the end, and would have been challenged and learned something. The reliable availability of a tool for learning (a computer patient) and being able to organise one's time and know there will be a productive outcome can be very satisfying. This may have been one of the key reasons why students kept using the program when so many factors worked against it.

Students' independence was also increased by not needing a tutor present to stimulate their learning. Working with peers was less threatening than a tutorial situation and they felt more freedom to ask questions of peers when unsure of something. This was both observed and reported by students.

Freedom to chose their own path through the program

One aim of medical education is to produce graduates who can reason independently, efficiently and effectively through a patient problem. Real patient problems normally present themselves with minimal information ("I have a pain in my chest"), after which the data gathering is dependent on the doctor, and information received from the patient (Barrows and Feltovich, 1987). The program does not have a sequential, predetermined, question-and-response path, therefore students must decide the course and order of their investigation. No constraints are put on their investigation other than efficiency limits, the requirement to define the problem, to generate differential diagnoses, and to interpret findings on some tests. These latter four factors are pedagogically important constraints aimed at encouraging a thoughtful approach to clinical problem solving.

7.1.2 Practice at Reasoning and Gauge of Knowledge

The DxR program design required students to integrate and apply knowledge. In the Four Year clinical setting, the application of knowledge to a patient problem is mainly restricted to tutorials, with limited opportunities outside this setting. Students found the program valuable as a tool to help them test and identify gaps in their knowledge (in cases where they had prior knowledge) and to practise problem solving.

7.1.3 Completeness of Patient Interaction

The real value of the program to students lay not so much in the history and examination, which they can learn by working with real patients and tutors, but in the completeness of the patient interaction. In a clinical setting, students are often only able to take a history (or part of a history) from a patient or do a physical examination (or part of a physical examination). It is rare that they follow one patient through to completion. While working through DxR cases, they could go further than a history and physical examination, and order laboratory tests, such as X-rays and blood tests, and interpret findings. If they chose to, they could also 'treat' the patient. This gave students an opportunity for a much greater breadth of learning than previously possible. It could be argued that because students can work through a complete patient problem, including test ordering, to reach a diagnosis, they are able to build a more integrated clinical picture of an illness. Feedback following the investigation helps ensure the clinical picture is accurate.

7.2 Learning

7.2.1 Learning From DxR Cases

Quantitative differences in learning were not measurable in this pilot study. This is consistent with many other evaluation studies on technological interventions in education (Clark, 1991). We believe one of the key factors contributing to this outcome was that cases were optional and not integrated into the assessable part of the curriculum (see 3.1). Because of these factors, limited emphasis has been placed on quantitative outcomes. Of greater interest in this pilot study were the qualitative aspects: did students value the program; how did they use it; did it stimulate clinical reasoning; and how could it be integrated into the curriculum? Although the examination showed no significant difference in knowledge, a great deal of qualitative evidence suggests that students were learning the skills of clinical reasoning (see 5.1): the cases provided opportunities to apply knowledge in a clinically relevant setting; it helped to test their knowledge and skills, supported a thinking approach; and encouraged metacognition through feedback.

Learning may also be occurring by helping students build a pool of exemplars in memory, i.e., providing a "hook" for students to hang a diagnosis on. This is in itself a desirable outcome, as expert knowledge is said to comprise not only an integrated knowledge base for clinical reasoning but a pool of "exemplars" or "instances" (Schmidt, Norman and Boshuizen, 1990) from which to draw. This type of learning was illustrated by students who worked through the paediatric abnormality case and immediately recognised it in a subsequent lecture (see 4.3).

> *"I think because you can see the people, you can see their faces, you've got names to them, it gives you something to hang diagnoses on, the same as patients in the hospitals. You remember that person had such and such."*

7.2.2 Learning in Groups

Working in groups (see 5.2), on a diagnostic problem worked in the sense of allowing students to reason through each problem at their own pace; they could stop mid-investigation and discuss issues. The free inquiry interface allowed them to structure their own investigation and only intervened in their investigation by requiring them to list and refine their diagnostic hypotheses, interpret findings and justify some decisions. Reasoning through and discussing a diagnostic problem cannot be done with such freedom when with a real patient in a tutorial situation, in fact students often report an inability to think when in a tutorial with a real patient and a tutor.

Despite the positive aspects of learning from other group members during DxR cases, findings regarding groups were mixed. Some groups functioned well, discussed cases, aired uncertainties and challenged each others line of reasoning, but other groups did not function well as a whole. Groups were chosen by a randomised process based on tutorial groups and some students worked with peers they would not normally chose to study or learn with. This resulted in reported incidences of some groups moving through cases with less discussion than certain members would have liked (focus group). The other problem was that a common, convenient time was difficult to organise for a group of people.

What is the optimal way for students to use the program: in groups or on one's own? Should Year Four students practise the skills of efficiently and effectively resolving diagnostic problems, on their own or in groups? There is obvious value in group interaction for fostering metacognitive skills and pooling knowledge, however, students ultimately need to resolve diagnostic problems on their own. Would the discovery of gaps in one's knowledge while working with DxR cases have a more powerful effect if working on one's own as opposed to a group? From the perspective of clinical educators and the information they can receive from DxR records, would there be greater advantage if they received feedback on individual students? For example, records of individual students could be used to track progress through the clinical years and potentially act as a predictor of diagnostic competency in later years.

Taking all of these considerations into account, perhaps an optimal arrangement is to ask students to work through each new case on their own, but provide an opening to revisit the case later with friends (or on their own again). This approach has a number of significant advantages: firstly students can gauge the depth of their understanding and the areas they need to revise when working on their own; secondly teachers have a record of the reasoning process of individual students for monitoring purposes and detection of problems, finally students are free to go back to a case and practise reasoning through it in a form that best suits their learning style (individually or in a group).

7.3 Faculty Concerns

7.3.1 Devaluation of real patients?

It was apparent from student responses that interactions with patients on the wards were highly valued and that computer cases could never replace real patient contact. Computer programs could not adequately simulate real patient responses to an interview and physical examination. However, the computerised patient cases did have a number of advantages over real patient contact: they were more accessible, less threatening and allowed some experimentation and mistakes (and therefore did not endanger a patient); they were self-paced and allowed discussion; and allowed them to investigate a complete case, diagnose, and check their own investigation immediately afterward, which they found challenging and rewarding. Students' type of interaction with the computerised patients differed, however. The evaluators feel that this may be due to contextual factors of the pilot study. Some students worked through a case as if the computer patient was real, for example, a test was not ordered if it was considered invasive and not warranted, or if the test was excessively costly compared to the information it was expected to contribute. Other students had a different attitude and liked being able to perform tests on patients and get results where they would not be able to in real life. The latter students used cases more like a tool for experimentation and observing outcomes on patients. The differences are reflected in the following statements from students:

> *"We stopped short of doing a muscle biopsy because we thought it seems too invasive and we had no idea of whether we should be doing it" "... and doing lots of invasive things to a patient when you're not going to get any information out of it is a complete waste of time and its not fair to the patient either."*

> *"It was probably one of the few situations where you could do absolutely anything to a patient that you wanted without them being annoyed. I mean you stick anything in..."*

What are behind these attitudinal differences, particularly with respect to test ordering, and what type of skills are encouraged by each outlook? The former group are using a thinking, humanistic approach to the art of medicine, which more closely parallels the thought processes and considerations desired in clinical practice. The second is more difficult to analyse. Do the second group of students see the computerised patient problem as a game to play, without thought to a real patient, or is it the result of students who are taking the program seriously but have limited understanding of the patient problem, and are over-testing (over-investigating) to try and discover the diagnosis through a shotgun approach?

In the pilot study, students were asked to use the program but were not given particular guidelines on its use. In addition, no accountability was built into the study, for example, records were not going to be viewed by teaching staff. It is likely that these contextual factors affected the way students perceived the computer patient. Would this situation arise if students were asked to perform their investigation as if it were a real patient, and their investigation was assessed (formatively or summatively)? And, would students have learned more from each case and shown significant differences in outcome (examination differences between study and control groups) if these factors had been built into the study? If the context was set and students still appeared to be ordering inappropriate and excessive tests, then their actions could be interpreted as lack of knowledge, rather than play.

This discussion reinforces the importance of setting the context for learning using multimedia, for example, the importance of stating the pedagogical rationale for introducing the program and stating how students are expected to use the program, record data, and whether their performance will be assessed. Realisation of the different attitudes students could take to the patient was an important outcome of the pilot study and has helped to inform the way the program will be used with the next group of fourth year students.

7.3.2 History taking / patient interview?

Patient interviewing skills (human interaction emphasis) are taught to students, which is distinct from 'history taking' (questions to resolve the problem, by differentiating between hypotheses). Prior to the commencement of the pilot study, faculty expressed a concern about the interview interface: that gathering information from a question bank might discourage students from developing the desired qualities of thinking about patients in terms of a human interaction that require empathy and consideration. To avoid this potential outcome it was recommended that the question data base be replaced by a "potted" history.

The "potted" history, however, was very unpopular with the students. Students felt it limited the information they could gather and did not allow them to adequately refine their differential diagnoses prior to the physical exam. The question database was therefore installed in place of the "potted" history for all remaining cases following case two.

Did students' interviewing skills and attitudes to real patients change as a result of working with computerised cases? No conclusive answer to this was reached in the pilot evaluation. It was beyond the scope of the evaluation to measure changes in student attitude to real patient interviewing before and after working through the DxR cases, but it was clear that students valued real patients for developing their interviewing skills and the computer interface for giving them a tool to think with and gather information.

Given the question-category design of the interview interface, what was the quality of the thinking that went into the history taking? Selecting a question category, means that one can then view (and select from) all items within a category. Does this lead to mental laziness and/or significant cueing effects on the part of the student? Questionnaire responses indicated that thirty two percent felt they randomly clicked through questions, while sixty five percent said they did not (Q38). Observations and discussions with students indicated that students were both scanning and searching. The degree to which they randomly or purposely worked through cases may reflect the context of this study in that no guidelines or accountability were built in. Response rates to this question may alter significantly in later studies if a context is first set.

During review of the paper a lively debate arose about the degree of cueing arising from the patient interview interface (see review discussion, *On the issue of "cueing"*: `www-jime.open.ac.uk/Reviews/get/bryce-reviews/32/1.html`). While the question bank is not totally uncued, the large size of the database and the consistency of the database across all DxR cases, means that cueing is minimised from case to case. This design also has some significant advantages in that it reduces the overall size of the program, and can remind students of questions they would not have otherwise considered if in a real situation (focus group). However, the question bank design is limited in the sense that it does not allow students to freely generate their own questions in the manner that a real situation, a natural language interface or an external keyword table format would (see review discussion). Although the interview interface is less flexible than the real world ideal, the evaluators feel that the advantages outweigh the disadvantages, and that to resolve any potential frustrations with this type of interface design students need to be informed of the rationale for the design when they first encounter the program.

The topic of altered history taking / interviewing skills as a result of using this program is an interesting one, and worth pursuing. Initial evidence from work in progress indicates that providing students with a platform (and tools) for thinking through clinical problems (DxR cases) may support a more thoughtful, and less stereotyped, approach to interviewing in subsequent real patient interactions. In the case in point, a student had worked through a pulmonary embolus problem on the computer, and later interviewed a patient with a similar cluster of symptoms. The symptoms triggered her to think of pulmonary embolism and she began to interview according to an hypothesis as opposed to a list of stereotyped questions with no clear thought as to the nature of the patient problem. This poses an interesting question: does diagnostic problem-solving with computer patients lead students to consider these diagnoses when working with real patients? If students are exposed to a large enough number of computer cases can they more readily recognise emerging "illness scripts" (Boshuizen and Schmidt, 1995) with real patients?

7.3.3 Cost awareness an advantage

Clinical educators felt that the raised awareness students had of the cost of tests was a valuable outcome, because cost considerations are not usually addressed in the early years of clinical training, and habits of excessive expenditure can be hard to curb later. Excessive test ordering is often an indication that the diagnostician has not effectively refined his/her differential diagnoses in the history and physical examination and is relying on the investigations to diagnose the problem (Griner and Glaser, 1982). Does a raised awareness of cost in Year Four, however, have a significant effect on the number and appropriateness of tests ordered by students, now or in later practice?

7.4 Proposed Integration in Year Four Medicine

7.4.1 Training / Educational Rationale

Although the program is intuitive as a whole, a number of minor problems in navigation were identified. This information was used to design a training session for future users. In this same session it was proposed to inform students of the educational rationale of the program, how to record data and what would be done with that data (*e.g.*, formative or summative assessment). At this session students also need to be informed of the context of use: that the computer patient be treated as a real patient in terms of the questions asked, the examinations performed and the tests ordered. This introductory session can therefore fulfil the critical function of training and setting the scene for learning from the program.

7.4.2 Case selection and content

Students felt their time was more effectively used if cases helped to consolidate their knowledge, rather than present new material to learn. It was therefore decided to introduce cases to students after they had studied the topic. It was also decided to have a clinician review (and modify where necessary) case content prior to student use. Because differences in American and Australian terms and units of measurement caused some confusion and wasted time, units and terms were altered to Australian standards.

7.4.3 Presentation of cases

It was decided to introduce cases to students by symptom (*e.g.*, chest pain) rather than by system (e.g., heart problem) (see 6.), so that students would reflect more broadly on the possible differential diagnoses, and not simply consider diagnoses within the system area.

7.4.4 Feedback

Feedback is a critical factor in learning (Laurillard, 1993; Norman GR and Schmidt, 1992; Jonassen and Hannum, 1987), and is provided by the program at two levels: immediate feedback i.e., a consultant gives a professional interpretation after the student has made his/her interpretation; and delayed feedback when the student has completed the patient problem and has committed to a diagnosis. Both forms of feedback are important. Delayed feedback is used when higher level learning is desired (Jonassen and Hannum, 1987).

While feedback on the investigation was at first considered novel and was greatly appreciated, in time students (particularly at one hospital) asked for more detailed feedback. The questionnaire response to 'I found the program helped me to learn by receiving feedback on my performance' (58%) (Q24) reflected this need for more feedback. Feedback can be increased by adding to the content of the computer feedback at the end of each case, however, it was decided to trial case "wrap-up" sessions with the subsequent cohort of students and explore the outcome of this on learning (work in progress).

7.4.5 Case "Wrap-up" Sessions

Case "wrap-up" sessions were conceived as large group sessions led by a single clinician, with the purpose of reviewing a case, and discussing issues related to reasoning through the clinical problem. The direction of discussion in the review sessions was to be partly guided by the student activity records generated by the program. The rationale for case "wrap-ups" was in more fully utilising the capabilities of DxR and a number of educational advantages for both students and teachers.

Advantage to students

The advantage of this arrangement for students is that, after each case, there is an opportunity to interact with a teacher and resolve areas of misunderstanding or issues raised by the case. Unlike a lecture on content, students are more likely to be engage in high level discussion if the they have reasoned through their own patient problem and committed themselves to a diagnosis. It is possible at these sessions to provide students with a summary (print-out) of their investigation as a stimulus for discussion.

Advantage to the teacher

The advantage for teachers of "wrap-up" sessions is that teachers learn, from the student activity record, how students are thinking and can direct feedback toward misconceptions and omissions. A window into students' thought processes is rare in clinical teaching, unless a 'safe', supportive environment is created (Grant, 1989). Even so, only the thought processes of the students who are actively engaged in the process can be witnessed. The advantage of the DxR program is that activity records of students' trails of logic can be organised, so that teachers can view both individual records, and a summary of the full cohort of students.

By providing "wrap-up" sessions after each case, students can learn more about how to think through a patient problem and identify where they are going wrong. Teachers can see where their teaching has been effective, ineffective or misinterpreted, and can reflect on what is needed to facilitate improved student learning.

7.5 How DxR Might Be Used In Medical Education?

DxR has the potential for a great many types of applications. It is currently used in the United states at all levels of medical education, both in traditional and problem-based learning curricula. It is used as the patient problem in PBL curricula, and to help embed and contextualise learning in traditional curricula. It is has been used both as a learning tool, and as an assessment tool (Myers and Dorsey, 1994). Students both in the early years of their education (year one) and students in clinical training (*e.g.*, paediatrics) have used it to hone their thinking skills and increase their exposure to cases. There are many possible ways of using DxR cases, however, it is important that the application reflects the needs of the learners and educators.

The evaluators of this program see all of the above as potential ways of using DxR. In traditional curricula, students are often presented with content but are not given opportunities to handle information. This is the greatest advantage we see of using DxR in Year Four of the traditional program at The University of Sydney. Together with case "wrap-ups" by a clinician, it could prove a very powerful tool for learning. Students have the opportunity with DxR cases to practise transforming their mental lists to meaningful constructs that can be later drawn on in clinical situations with patients. Teachers have the opportunity to gauge students' level of understanding in an ongoing fashion throughout the year, which is limited in tutorial situations, but is important for reflecting on and improving teaching practices. A step further in the application of DxR is to use it as a tool to identify students with problems in real clinical reasoning. In this sense, it has potential for identifying students, who may need some form of remedial intervention. Often students with problems are not identified until final examinations when it is too late to provide assistance.

Long term, with interested clinicians, DxR could be used to transform the role of the teacher from a conveyer of content (lectures) toward a facilitator of high level learning ("wrap-up" sessions which discuss how to apply knowledge in the clinical context). Students are often disillusioned by lectures that simply give them lists, and repeat information they can find in text books. They are greatly in need, however, of practise in applying knowledge and solving clinical problems. What would be the effect on teachers and learners if lectures, describing illness and disease, were replaced by review sessions on specially selected (or created) DxR cases? Would students be more empowered to become active, confident, self-directed learners, and would teachers enjoy interactions with students at a more stimulating, higher cognitive level?

8. Conclusions

The pilot study was aimed at determining the potential of the program, how it could be used and whether faculty concerns were justified; it was voluntary and not assessable. The study found that students valued the program and perceived it as an effective educational tool if used appropriately. It was fun to use and non-stressful. The interface was easy to navigate with a few exceptions that can be addressed in a training session, however, cases needed to be 'Australianised' (*e.g.*, converted to Australian units of measurement). This was later carried out. The program stimulated learning and clinical reasoning, however, students felt they got more value from the program if cases followed lectures and tutorials. This allowed them to work through cases systematically, gauge their depth of understanding and reinforce their learning and, as a result, gave them a greater sense of satisfaction.

Group work had its advantages and disadvantages for learning. It worked well for some groups and less well for groups who did not communicate effectively with each other. However, students ultimately need to diagnose efficiently and effectively, on their own. Therefore a case can be made for learning in both modes. One suggested ideal mode of use is to have students work through cases on their own at first, but provide the option to re-work a case later, with a friend or on their own. This approach produces a record of individuals for faculty and an opportunity for students to gauge their personal level of understanding, with the option to go back to the case to try to improve their performance and learn from peers.

Faculty were satisfied that students did not devalue real patient interaction as a result of working with computerised patients. It was found that in fact DxR added to the clinical setting in a number of ways: the cases added to the pool of diagnostic problems students were exposed to; students could apply their knowledge using a free inquiry interface and learn through practice and feedback; and computer patients were accessible when real patients were not, which was an effective use of otherwise free time. It also provided opportunities to work through complete patient cases independent of a tutor's presence, which was previously not possible in the clinical setting.

The study found that students' reasoning processes were inhibited if they were given a 'potted' history and not allowed to select questions from the question database. Although selecting questions from a database was not seen as optimal and could provide some cueing within question categories (7.3.2), it allowed students the freedom to narrow down their investigation, that a 'potted' history did not allow, and helped to remind them of questions to ask in a patient interview. The history database could not simulate a real interview, however it could provide a framework for inquiry.

Students reacted to the computer patient in one of two ways: as if the patient was real; and as a platform for experimentation. The evaluators feel that this may have resulted from not setting a context for how the program was to be used, and that students should be asked to approach the investigation as if the patient were real in order to avoid ambiguity in interpreting student actions (*e.g.*, excessive test ordering), and to discourage shotgun approaches to solving clinical problems. Asking students to treat the patient as if it were a real patient, when considering the interview, physical examination and laboratory tests is more likely to encourage a thoughtful, reasoned approach and to foster and refine the skills important for clinical practice. Students in Year Four medicine wanted more feedback from cases. This could be addressed by modifying the content of computer feedback to students, however it was decided to trial the introduction of teacher-led feedback with the next cohort of students, whereby teachers would use the 'trail of logic' records generated by the program to identify gaps in knowledge and direct teaching of the clinical reasoning process. This can serve the educational purpose of informing teachers how well students reason through clinical problems and can help student learning by providing a more interactive form of feedback through discussion. The case "wrap-up" approach is currently being evaluated.

An important outcome of the study was that the program had a great deal of potential for stimulating the clinical reasoning processes of Year Four students. However, a computer program alone is not enough to stimulate learning effectively. An appropriate context must be set for using the program, and guidelines for its use clearly stated. In addition, for increased student participation and commitment to learning the evaluators recommend the program be closely integrated with the teaching and made assessable (either formatively or summatively).

DxR can be used as a learning tool for students and as a tool for faculty and teachers to gauge students' diagnostic skills. It provides a relevant context for students to apply, restructure and refine their knowledge base. It can also potentially transform teaching in the clinical years (7.5). With thoughtful application it may prove to be not only an educationally effective tool, but an economically effective one.

References

Barrows, H.S. (1990). Inquiry: *The Pedagogical Importance of a Skill Central to Clinical Practice*. Medical Education, 24, 3-5.

Barrows, H.S. and Feltovich, P.J. (1987). *The Clinical Reasoning Process*. Medical Education. 21, 86-91.

Boshuizen, H.P.A, and Schmidt, H.G. (1995). *The Development of Clinical Reasoning Expertise*. In: Higgs J and Jones M (Eds.), Clinical Reasoning in the Health Professions. Butterworth-Heinemann Ltd: Oxford, pp. 24 - 34.

Clark, R.E. (1991). *When Researchers Swim Upstream: Reflections on an Unpopular Argument About Learning from Media*. Educational Technology, 31,(2), 34-40.

Coles, C. and Holm, H.A. (1993). *Learning in Medicine: Towards a Theory of Medical Education*. In: Coles, C. and Holm, H.A. (Eds.), Learning in Medicine. Scandinavian University Press: Oslo, pp. 189-209.

Grant, J. (1989). *Clinical Decision Making: Rational Principles, Clinical Intuition or Clinical Thinking?*. In: Balla, J.I., Gibson, M. and Chang, A.M. (Eds.), Learning in Medical School: A Model for the Clinical Professions. Hong Kong University Press: Hong Kong, pp. 81-100.

Griner, P.F. and Glaser, R.J. (1982). *Misuse of Laboratory Tests and Diagnostic Procedures*. New England Journal of Medicine, 18, 1336-1339.

Higgs, J. and Jones, M. (1995). *Clinical Reasoning*. In: Higgs J and Jones M (Eds.), Clinical Reasoning in the Health Professions. Butterworth-Heinemann Ltd: Oxford, pp. 3-23.

Jonassen, D.H. and Hannum, W.H. (1987). *Research Principles for Designing Computer Software*. Educational Technology, December, pp. 7-14.

Laurillard, D. (1993). *Rethinking University Teaching: A Framework for the Effective Use Of Educational Technology*. Routledge: London.

Lyon, H.C., Healy, J.C., Bell, J.R., O'Donnell, J.F., Shultz, E.K., Moore-West, M., Wigton, R.S., Hirai, F. and Beck, J.R. (1992). *PlanAlyzer, an Interactive Computer-Assisted Program to Teach Clinical Problem Solving in Diagnosing Anemia and Coronary Artery Disease*. Academic

Medicine, 67, 821-828.

Masys, D.R. (1989). *Information Technology and Undergraduate Medical Education*. Academic Medicine. 64, (4), 187-190.

Myers, J.H. and Dorsey, J.K. (1994). *Using Diagnostic Reasoning (DxR) to Teach and Evaluate Clinical Reasoning*. Academic Medicine, 69, (5), 428-9.

Newble, D., van der Vleuten, C. and Norman, G. (1995). *Assessing Clinical Reasoning*. In: Higgs J and Jones M (Eds.), Clinical Reasoning in the Health Professions. Butterworth Heinemann Ltd: Oxford, pp. 168-178.

Norman, G.R. and Schmidt, H.G. (1992). *The Psychological Basis of Problem-Based Learning: A Review of the Evidence*. Academic Medicine, 647, (9), 557-565.

Ramsden, P. (1992). *Learning to Teach in Higher Education*. Routledge Press: London.

Schmidt, H.G., Norman, G.R. and Boshuizen, H.P.A. (1990). *A Cognitive Perspective on Medical Expertise: Theory and Implications*. Academic Medicine, 65, 611-21.

Appendix: Questionnaire And Responses

The Questionnaire below was distributed to Year IV students following completion of the last DxR case. Thirty one students in the study group (59%) completed the questionnaire.

Guide to Questionnaire Responses

The bracketed numbers after each question indicate the responses to the question, expressed as a percentage.

For example:

(45, 35, 3, 10, 7) indicates 45% definitely agree, 35% agree, 3 % undecided, 10% disagree, 7% definitely disagree.

Faculty of Medicine The University of Sydney

QUESTIONNAIRE: PERCEPTIONS OF THE COMPUTERISED INTERACTIVE PATIENT PACKAGE

Only students in Group B of the interactive patient problem trial need fill in this questionnaire.

This questionnaire is designed to explore your experience of working with the package, your perceptions of the activities it contains, and your views on how it may act as an adjunct to learning.

Note that it is not being implied that packages like DxR should replace face-to-face teaching in the undergraduate medical program; we are seeking your help in investigating how such packages might enhance learning in the normal curriculum.

Please fill in the answer next to the appropriate question on the General Purpose Answer Sheet using the code:

1 means **definitely agree**
2 means **agree (with reservation)**
3 only to be used if the item doesn't apply or if you find it impossible to give a definite answer
4 means **disagree (with reservation)**
5 means **definitely disagree**

Section 1 - Using the Computer-based package

Q1 I am usually comfortable using computers (45, 35, 3, 10, 7)
Q2 I enjoy using good computer programs to assist my learning (35, 45, 3, 13, 3)
Q3 I felt the program was, on the whole, easy to navigate (7, 61, 7, 26, 0)
Q4 I felt navigation would have been relatively easy if training was initially provided (42, 23, 10, 23, 3)

Section 2a - Developer's Intention

I felt the interactive patient program was DESIGNED to:

Q5 sharpen my thinking processes (45, 42, 3, 7, 3)
Q6 test my knowledge (48, 32, 7, 10, 3)
Q7 identify gaps in my knowledge (48, 35, 7, 10, 0)
Q8 stimulate me to learn about a subject I knew little about (23, 58, 10, 7, 3)
Q9 help me to learn in an environment where it was OK to make mistakes (39, 45, 3, 10, 3)
Q10 *replace* real patient contact (7, 3, 7, 35, 48)
Q11 act as an *adjunct* to real patient contact (26, 58, 3, 10, 3)
Q12 help me practise reasoning through a patient problem (45, 42, 3, 7, 3)
Q13 help me to develop my investigative skills (29, 52, 10, 10, 0)

Section 2b - Learning from the package

I found the program helped ME to:

Q14 sharpen my thinking processes (39, 32, 10, 19, 0)
Q15 test my knowledge (45, 45, 0, 10, 3)
Q16 identify gaps in my knowledge (45, 45, 0, 7, 3)
Q17 *organise* my knowledge (16, 55, 10, 13, 7)
Q18 learn by providing an environment where it was safe to make mistakes (45, 35, 0, 19, 0)
Q19 *practise* reasoning through a patient problem (48, 42, 7, 0, 3)
Q20 improve my clinical reasoning skills (35, 45, 3, 13, 3)
Q21 build confidence in reasoning through real patient problems (35, 29, 10, 19, 7)
Q22 be selective in my choice of questions, tests and exams (32, 42, 3, 23, 0)
Q23 learn by investigating a patient problem *through* to completion (32, 35, 13, 16, 3)
Q24 learn by receiving feedback on my performance (23, 35, 13, 26, 3)
Q25 become more conscious of the *necessity* of tests in terms of overall cost (42, 45, 3, 7, 0)
Q26 stimulated me to learn about things I knew little about (16, 45, 23, 13, 3)

Section 3 - How you used the package:

Q27 I found that working in a group work helped me to learn (35, 32, 10, 13, 10)

Q28 I found group work did not help me learn (10, 16, 16, 26, 32)
Q29 group work helped me learn because I had to justify my decisions (35, 29, 19, 10, 7)
Q30 group work helped me learn because I could ask others if I didn't understand something (29, 32, 19, 16, 3)
Q31 group work helped me learn because the sum of the group knowledge was more than mine alone (42, 29, 16, 13, 0)
Q32 My overall experience of the program was enjoyable (42, 29, 16, 10, 3)
Q33 During or after using the program I have looked up information related to the case (19, 29, 7, 32, 13)
Q34 Identification of gaps in my knowledge triggered me to return to clarify that area (26, 42, 7, 23, 3)
Q35 I have applied what I have learned from the program in a real patient situation (3, 29, 16, 35, 16)
Q36 In the first two cases, I was frustrated by blocked access to the full list of history questions (58, 19, 13, 10, 0)
Q37 I found not being able to ask history questions affected my consideration of differ ential diagnoses (58, 26, 7, 10, 0)
Q38 I clicked randomly through the history questions (19, 13, 3, 39, 26)

Section 4 - How the package could best be used to enhance learning:
Q39 I feel, used appropriately, the program is an effective learning tool (58, 29, 3, 10, 0)
I feel that this program would best help me in 4th year if:
Q40 initial instruction on how to use the program was provided (58, 32, 0, 7, 3)
Q41 units and terms were consistent with those used in Australia (58, 23, 3, 7, 10)
Q42 cases were timely and relevant to what we are currently learning (58, 29, 3, 7, 3)
Q43 cases were grouped by system (eg. cardiology, haematology) (39, 39, 3, 13, 7)
Q44 cases were grouped by symptom (eg. shortness of breath) rather than by system (35, 29, 0, 32, 3)
Q45 a pool of unknowns was provided (42, 32, 16, 3, 3)
Q46 the computers were in a convenient and accessible location (58, 23, 7, 7, 3)
Q47 access hours were extended (48, 26, 10, 13, 0)
Q48 I could also use the program on my own if I chose to (59, 29, 7, 3, 0)
Q49 I could use program in groups that I chose to be in (42, 29, 3, 16, 7)
Q50 cases were followed up by a tutorial discussion (wrap-up session) (32, 39, 10, 10, 7)