Chapter 1 Introduction

With the rapid growth in medical knowledge, and associated changes in medical practice, it is important that there are effective means for primary and continuing medical education. Unfortunately, there is evidence to suggest that there are serious shortcomings with existing approaches to continuing medical education (Davis et al., 1999). Simulated medical learning environments are one way of providing interactive experiences, which enable learners to practice what they have learned. This approach has been shown to be more effective at changing physician behaviour than more traditional methods of continuing education (Davis et al., 1999). Learner reflection is a process that has been promoted as having great potential for improved learning for professional practice (Schön, 1987), although it has been underutilized in medicine (Branch and Paranjape, 2002). This thesis explores the support of learning through reflection, in the context of medical students and practitioners, working through a series of simulated consultations involving the diagnosis and management of chronic illness.

When exploring approaches to medical education, it is first necessary to have an understanding of medical problem-solving, and the practice of medicine. Therefore, this chapter begins with a brief introduction to medical problem-solving. This is followed by and introduction to the concept of learner reflection, with a particular focus on its role in learning for professional practice. The chapter then goes on to look at simulated medical learning environments as a way of providing interactive experiences, which enable the learner to practice what they have learned. The need to include medical decision-making and patient management within the simulation environment, especially in the context of chronic illness, is also considered. Based on this introductory information, a model of the medical consultative process is described, as well as a model for reflection that is congruent with the consultative model. These models have been embodied in SIMPRAC, which aims to support learning about the diagnosis and management of chronic illness over several simulated consultations by encouraging learner reflection.

1.1 Medical Problem Solving

Before developing software to help medical students and medical practitioners learn, it is first necessary to have an understanding of the clinician's approach to medical problems. Knowledge of this reasoning process, especially the differences between less experienced clinicians and more experienced clinicians, can then be used as a foundation for developing an environment capable of improving learning outcomes.

Research in medical problem-solving has been undertaken for several decades but only recently has this been reflected by changes in the way medicine is taught. The classical text on this area of study was written by Elstein, Shulman and Sprafka, based on research they undertook in the early 1970's (Elstein et al., 1978). They view clinical problems as ill-structured problem domains where not all the information required to solve the problem is immediately available but must be gathered and evaluated over time. As information is gathered, the problem is progressively better defined. Furthermore, these data are probabilistic in nature and may have alternate interpretations. They suggest that hypothetico-deductive reasoning and early hypothesis generation is used by experienced and inexperienced clinicians to solve clinical problems. Hypothetico-deductive reasoning involves the initial acquisition of basic data from which only a small number of hypotheses are generated. Most clinicians generate on average, four to five hypotheses with an upper bound of six to seven. Further data are then collected to test and refine the true hypotheses, and exclude the false hypotheses. Clinicians were observed to move to structured, routine data collection when they needed time to interpret information that had been provided to them. If this "routine" questioning identified information that might generate new insights, they then reverted to selective, hypothesis-driven questioning to explore the new avenue.

Research by other groups has suggested that medical problem-solving by experts involves pattern recognition or illness scripts based around knowledge of the clinical consequences of the disorder (Schmidt et al., 1990). According to Schmidt and others (1990), medical students initially try to understand their patients on the basis of causal pathophysiological mechanisms. Later, as they gain more experience, there is a move to simplified mental models that are sufficient for diagnosis and management, with a focus on the features that characterize the disease. For example, a student may initially understand myocardial ischaemia in terms of reduced coronary blood flow leading to myocardial hypoxia, which in turn leads to disruption of metabolic processes within the myocyte. These metabolic disturbances lead to increased levels of lactate and other intermediates that activate nocioceptors, resulting in the perception of pain. These disturbances also lead to impaired muscular contraction and reduced cardiac output causing a fall in systemic blood pressure, and increased end diastolic pressure. The latter, may in turn lead to pulmonary congestion, hypoxia, and subsequent feelings of shortness of breath. Furthermore, these metabolic disturbances can also lead to impairment in electrical conduction through the heart with depolarization and repolarization defects being apparent as changes on the electrocardiograph. In contrast, a more advanced student may just note that myocardial ischaemia may be associated with chest pain, dyspnoea (shortness of breath), hypotension, and changes on the electrocardiograph. When seeing a patient, practitioners are thought to select an appropriate script, verify the patient’s presenting features against the script, and if appropriately matched, manage the patient based on this understanding. Elstein et.al. have countered this by suggesting that problems familiar to the clinician might be resolved using this technique but more difficult cases, outside of frequent experience, need to be solved using a hypothetico-deductive approach (Elstein et al., 1990).

Models have been developed to describe the medical problem-solving process. Social judgement theory is one such model (Engel et al., 1990). This is a cognitive theory of human judgement, which emphasizes the uncertainty inherent in the physical, biological, and social environments (termed the ecology) in which judgements are made. The cues are the pieces of clinical information available for policy considerations. In this context, a policy refers to a decision on how the information is to be used and its importance. These cues vary in how they correlate with the clinical state of interest (ecological validity) and with how they are used by the clinician when making judgements (utilization validity). Cues may also vary in terms of their relationship to each other.

Hammond and his associates have developed a quantitative methodology and a lens model equation (Tucker, 1964) where achievement is the sum of a linear component comprised of the person's consistency, knowledge, and task predictability and a second component involving the non-linear usage of the cues. "The methodology relies on multiple regression statistics for creating a quantitative representation of the physician's judgement policy in the form of weights assigned to the variables, used as cues, in the judgement task" (Engel et al., 1990). It should be pointed out that while this model may well be able to describe the outcome of a physician's judgement in a given situation, it does not necessarily describe the process by which that clinician is able to arrive at the judgement. Having said that, this model still has significant practical application.

Studies of variation among clinicians have suggested that a lot of differences occur as a result of the different weights that different clinicians apply to the same cues (Kirwan et al., 1983). As the physicians in the study by Kirwan were senior medical staff (specialist rheumatologists), there is a suggestion that the degree of variation does not decrease with increasing experience.

It has been shown, that providing users with a comparison of their own cue weights to the optimal cue weights using computer analysis and graphics when solving a judgement task enhances the learning of complex judgement tasks (Hammond, 1971). An important pointer for improved teaching comes from Hammond's observation that this technique was more effective than providing the learner with outcome feedback or information about the nature of the task given before the trial (feed forward). Similarly, Kirwan et.al. (1983) were able to demonstrate a significant reduction in variability between physicians in the assessment of disease activity in rheumatoid arthritis when they were given feedback on their apparent cue weights compared to optimal cue weights. In contrast, providing outcome feedback made no difference to the congruence between physicians. This method of cognitive feedback via apparent versus optimal cue weights, is especially useful where there is a well-defined problem and clinical pathway. However, it may still be of use in ill-structured problems to reduce variation by allowing comparison against the group norm. In other words, this data suggests criterion-referencing should be undertaken where possible, where the user can compare their approach or activity against the optimal process. Where there are not sufficient validated criteria, then normative referencing, by enabling a user to compare themselves to a peer group, can improve learning.

1.2 Learning through reflection

As referred to above, medicine and its practice is a complex and ill-structured domain (Elstein et al., 1978). One method that has been promoted as a way to learn about practice in professions, such as medicine, is that of reflection (Schön, 1987).

Traditional medical education has largely been based on an objectivist view of learning. This model holds that knowledge exists independent of the learner, and is something that can be acquired and transferred between individuals. In contrast, the constructivist view holds that learning is a constructive process, in which the learner builds their own representation of the knowledge space by negotiating multiple perspectives within a given context. This latter representation is internal to the individual and there is no shared reality. Furthermore, the constructivists hold that learning should occur in a realistic setting, reflecting real world situations (Merrill, 1991, Spiro et al., 1991a, Bednar et al., 1995). This view is held in the belief that some knowledge is context dependant, and cannot be learned independently of the context in which it is used (Anderson et al., 1995b). In terms of professional education, this means that learning should take place in the context of professional practice.

Reflection and reflective practice is one constructivist approach that has been promoted as a means to learn from experience (Schön, 1987, Branch and Paranjape, 2002, Ruth-Sahd, 2003). The idea of reflective practice has been attributed to Dewey who in 1933 stated that, “reflective thinking is closely related to critical thinking; it is the turning over of a subject in the mind and giving it serious and consecutive consideration”

(Dewey, 1933 p. 3). Others such as Schön (1983), Boyd and Fales (1983), and Boud et. al. (1985) have continued the development of the theory.

In keeping with constructivist notions of learning, Schön holds that professional knowledge involves a degree of what he terms, “artistry” that can only be developed through practice within an appropriate context (Schön, 1987). He promotes the central idea of reflection as the means by which the student and practicing professional can maximise learning. Firstly, he describes the concept of *reflection-in-action* where one reflects on an activity as the activity unfolds. These reflections then guide the future direction of the activity. This is also referred to as, “thinking on your feet” (p. 26). Secondly, he describes *reflection-on-action*, where one reflects on the actions that have been taken, such that more appropriate action can be taken should a similar circumstance arise. Thirdly, he also describes *reflection on the reflection-in-action*. By this, he refers to the ability of an individual to think about what they were thinking at the time the activity was carried out. He believes that this last type of reflection leads to the best learning. Others have described this as *reflection-for-action* (Ruth-Sahd, 2003).

Boyd and Fales (1983 p. 100) define reflection as:

> *“The process of creating and clarifying the meaning of experience (present or past) in terms of self (self in relation to self and self in relation to the world). The outcome of the process is changed conceptual perspective. The experience that is explored and examined to create meaning focuses around or embodies a concern of central importance to the self.”*

They also state that the, “process of reflection is the core difference between whether a person repeats the same experience several times, becoming highly proficient at one behaviour or learns from the experience in such a way that he or she is cognitively or affectively changed”. That is, by using the reflective process, learners have a greater chance of being able to generalize their knowledge so that it can be applied to new situations and experiences. Boyd and Fales (1983) suggest this ability to generalize knowledge and apply it to new situations differentiates a technician from the professional.

In their discussion of reflection, Boud et. al. (1985) have emphasized the affective nature of reflection. They list three elements that they consider are essential to the reflective process. These are, returning to the experience, attending to feelings, and re-evaluating experience. By, “returning to experience” they mean recalling the key elements and features of the experience. Attending to feelings has two components. The first is to use positive feelings that may include recollection of positive aspects of the experience, or those aspects associated with enthusiasm for potential benefits derived from processing the events. The second component is to remove obstructive feeling, as only after these have been removed, can a rational consideration of the events be achieved. The third element, “re-evaluating experience” involves examining the experience in light of any new knowledge and integrating it into the learner’s conceptual framework. Based on the work of Boud and others, Atkins and Murphy have outlined a three stage model for reflection (Atkins and Murphy, 1993). The first stage involves an awareness of uncomfortable feelings and thoughts arising from the realization that the current level of knowledge is insufficient to manage the situation. The second stage involves critical analysis of the situation. This is a constructive process that may involve examination of feelings and knowledge. The third stage involves a conceptual change with the development of a new perspective, which may or may not lead to changes in future actions.

Over recent years a number of benefits have been asserted for reflective practice. These have been summarized in a recent review by Ruth-Sahd (2003) and include: the integration of theoretical concepts within practice (Davies, 1995, Scanlan et al., 2002), enhanced critical thinking and judgment-making in complex situations (Clouder, 2000), increased learning from experience (Atkins and Murphy, 1993), reduced anxiety associated with the learning environment (Davies, 1995), and enhanced self-esteem and acceptance of professional responsibility (Johns, 1995). Most of the studies regarding the outcome of reflective learning have involved qualitative methods. However, a quantitative study using post-intervention testing only, found no significant difference in the test scores achieved by those who had received teaching using reflective methods, compared to those who had received more traditional teaching (Lowe and Kerr, 1998). The authors did note that the teaching methods were new to the students, and for a new curriculum, it is significant that they performed no worse. Therefore, while unable to demonstrate an outcome advantage for the reflective approach, these authors were still in favour of using this approach in association with traditional methods.

In their review of the literature, Atkins and Murphy (1993) have identified five skills they considered necessary for reflective practice and learning. Firstly, learners need to be self-aware so that they can honestly examine how a situation has affected them, and how they have affected the situation. Secondly, learners need to be able to give a comprehensive account of the experience. Thirdly, learners must be able to critically analyse an experience by being able to identify existing knowledge, challenge assumptions and explore alternatives. Fourthly, they must be able to synthesize and integrate information. Lastly, they need to be able to evaluate their new perspective. They go on to suggest that attention needs to be given to the development of these skills for reflective abilities to be engendered.

Having described briefly the practice, process and possible benefits of reflection, and the skills required for reflection, one must consider possible strategies for supporting reflection. Journal-writing has commonly been used (Mallik, 1998, Ruth-Sahd, 2003) on the basis that, “it may enable practitioners to make explicit the knowledge that is implicit in their actions” (Atkins and Murphy, 1993). Other commonly used methods have been reflective teaching portfolios, and dialogues or debriefings where learners can discuss their experiences as a group (Mallik, 1998, Ruth-Sahd, 2003). Imel (1992) has listed a number of reflective processes that can also be used to support learners. These include:

- Questioning what, why and how things are done.
- Asking what, why and how others do things.
- Seeking alternatives.
- Keeping an open mind.
- Seeking the underlying rationale or theoretical basis.
- Viewing from various perspectives.
- Asking, “what if…?”
- Asking for the opinion and viewpoints of others.
- Considering consequences
- Hypothesizing.
- Synthesizing and testing.

- Seeking identifying and resolving problems.

If, as previously mentioned, medical knowledge and medical problems represent ill-structured domains (Elstein et al., 1978), then reflection provides a tool that enables practitioners to continuously re-structure their own cognitive model of the knowledge space based on experience and new information, which in turn leads to increased understanding. Schön (1987) saw reflective learning as having application to a wide range of professions, including the health professions. While it has been present in teacher education for some time (Mallik, 1998), and has been proposed as having an important role to play in medical education and professional development (Shapiro and Talbot, 1991), it has generally been underutilized in medical education (Branch and Paranjape, 2002). In distinct contrast, the nursing profession, which has similar difficulties with the so called “theory-practice gap” (Mallik, 1998), has widely adopted the reflective-learning model (Burnard, 1995, Davies, 1995, Johns, 1995, Ruth-Sahd, 2003). In fact, the Australasian Nurse Registering Authorities have gone so far as to include this as a domain within their competency statements (Mallik, 1998). Given the potential for improved learning within the medical domain when using reflection, and considering that the reflective approach results in outcomes no worse than traditional methods, the design of effective learning environments should include support for the process of reflection.

1.3 Simulated medical learning environments

Traditional training in medicine involves a long period of formal education followed by, or in association with, an apprenticeship that involves practice on human beings (Issenberg et al., 1999). Unfortunately, in recent years there has been a reduction in the time available to physicians for teaching students, as well as a reduction in the availability of patients as an educational resource. A number of factors have led to this situation: many patients are now being managed outside of the teaching hospital, clinical periods for students have been considerably shortened, and increasing medical knowledge has resulted in the addition of new subject areas to the curriculum. Furthermore, in some cases, ethical considerations make some patients unsuitable for students (Bergin and Fors, 2003, Issenberg et al., 1999, Prideaux et al., 2000).

Having graduated, medical practitioners, like other professionals, continue learning through the whole of working life (Brna et al., 2000). This has traditionally involved modalities such as rounds, educational meetings, conferences, refresher courses, seminars, lectures, workshops, and symposia, often similar to those used in traditional basic medical education. Unfortunately, these modalities are often ineffective in mediating improvements in patient care through changes in physician behaviour (Davis et al., 1999). On the other hand, interactive continuing medical education sessions that enable the participant to practice skills can effect behavioural change (Davis et al., 1999). This combination of factors has led us to explore the potential role of simulation-based teaching systems to support long-term learning for medical practitioners.

When simulating human medical diseases and conditions, the most authentic environment is achieved by the use of trained actors (Elstein et al., 1978). Attempts have been made at developing alternative simulation environments, including paper-based systems (McCarthy and Gonnella, 1967, McGuire and Babbott, 1967). With recent improvements in technology it has become possible to develop computer-based simulations or so-called virtual patients, although there has been considerable variation in how these have been structured (Melnick, 1990, Friedman, 1995). Initial computer-based simulations were electronic versions of their paper-based counter-parts but with advancements in technology, rich multimedia environments have been developed (Bryce et al., 1997). With the development of the Internet and the World Wide Web, multimedia environments have become readily accessible over a widely distributed network. This enables much wider and more flexible access to these resources. However, web-based simulations have usually lacked the features and richness found on desktop systems (Hayes and Lehmann, 1996) due to limitations of bandwidth, browsers and cross-platform programming.

While learning theory might suggest that simulation-based teaching systems are an appropriate method of supporting learning, they do have their limitations. With previous medical case simulations, computer-based or otherwise, it has been consistently observed that there is considerable case-specificity (Elstein et al., 1990, Fitzgerald et al., 1994). That is, medical practitioners or students may be able to perform one case well but do poorly on a different but not altogether, different case. One approach to this problem has been to increase the number and breadth of the cases when using them as an evaluation tool for assessing clinical problem-solving skills (Clyman and Orr, 1990, Melnick, 1990).

Based on their studies of simulations using trained actors, Elstein, Shulman and Spafka (1978) found that the differences between the experts and the less expert problem solvers was to be found in the detail of their cognitive models consequent to their experience. Of particular interest, they found no statistically significant correlation between the thoroughness of data collection and the accuracy of data interpretation. Furthermore, Anderson et al. (1995b) suggest that optimal learning occurs when a combination of abstract and situation-specific training is provided, and that abstraction promotes the transfer of knowledge and thus insight from one situation to another. As they describe it, abstract training refers to the teaching of general principles, which are often a component of larger activities, and can be applied to a number of contexts. For example, in the situation of medical practice, one might provide instruction on the elements of good history-taking. For, without the skill of thorough history-taking, it is not possible to diagnose or manage complex medical problems. In the context of a simulation-based learning system, this means that we should take care to go beyond a specific simulation of one or more cases. Based on the work of Schön (1987), and as alluded to above, encouraging the user to reflect on their activity and their own thought processes, may assist with the process of abstraction and transfer.

While diagnosis, involving history taking, physical examination, and review of investigations, is critical to the appropriate management of the patient, it is only part of the consultation. The other component is medical decision-making. “Medical decision-making occurs throughout the diagnostic and treatment process. It involves the ordering of additional tests, requests for consults, and decisions regarding prognosis and treatment” (Braunwald et al., 2001). For effective medical decision-making and management of the patient, there must be an understanding of the natural history and pathophysiology of the disease process (Braunwald et al., 2001), as well as a broad knowledge of appropriate management strategies.

A limitation of most computer-based medical simulations is that they have been developed with an emphasis on medical diagnosis, and generally involve a single patient encounter. In contrast, much patient morbidity is associated with chronic diseases, such as diabetes mellitus and cardiovascular disease. These chronic disorders evolve over time and involve multiple doctor-patient encounters. These involve interactions of diagnosis and management that must be modulated or altered by the doctor and patient, depending on the development, progression and control of the disease and the emergence of superimposed pathology. Thus any simulation that intends to more accurately simulate actual practice should include this as a design element within the application model.

1.4 Reflection and the consultation process

In light of the importance of reflection for improved learning in medical practice, the following model of reflection, in association with the consultative process, is introduced. This model has two parts, a consultative process, and an associated layer of

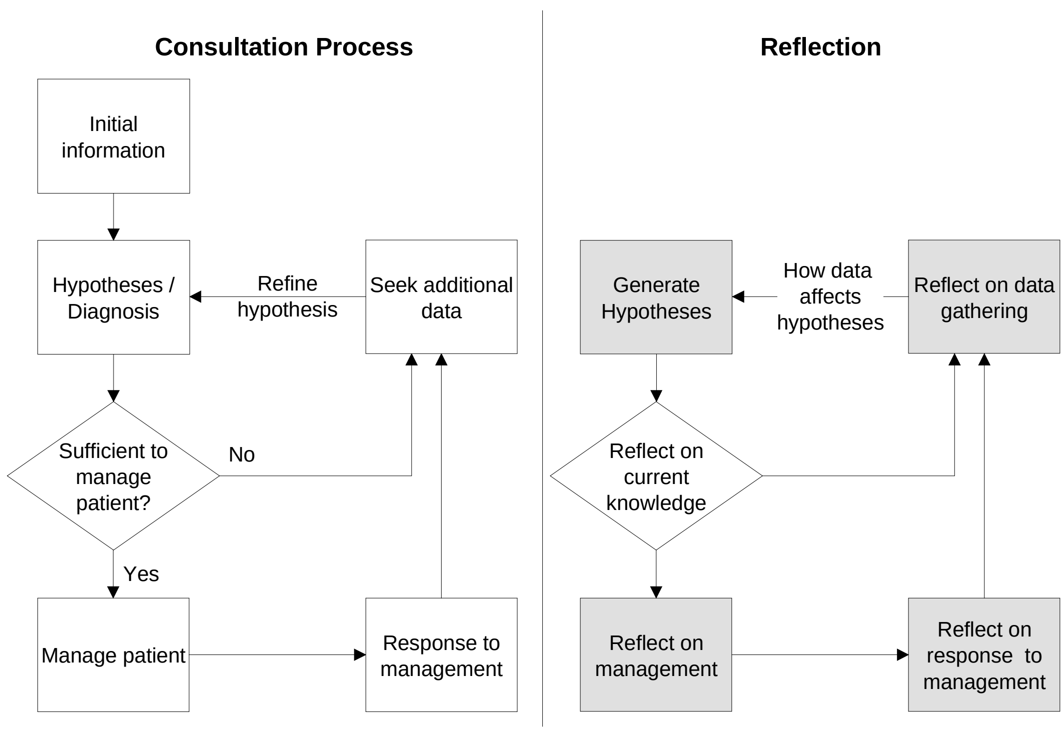

Figure 1: Model of the consultation process. Reflective processes explicitly supported in SIMPRAC are shaded grey.

reflection. This section describes both of these in terms of Figure 1, and begins with a description of the consultation process, based on standard medical models. This is followed by a description of the reflective overlay, a new model, developed as a foundation for the design of SIMPRAC.

While based on the hypothetico-deductive approach to medical inquiry, the model for the consultation process is not concerned with specific ideas regarding aetiological processes, so it also can be applied to the medical scripts approach. In the latter, the initial information cues a relatively mature set of hypotheses regarding the presence of a particular disease processes, and subsequent data gathering is aimed at confirming that diagnosis and excluding alternative explanations.

For example, suppose a patient presents with severe crushing chest pain. If a hypothetico-deductive approach is taken, then one would generate a series of hypotheses regarding the chest pain. For instance, the pain may be considered to be coming from the heart, the oesophagus, other mediastinal structures, or radiating from the abdomen. Further questioning would then be undertaken to refine the hypotheses. If exploring the heart as a source of pain, one could ask about radiation of the pain to the neck or arms, associated shortness of breath, or a sensation of palpitations. The hypotheses might then be refined to include such possibilities as myocardial ischemia, myocardial inflammation (myocarditis), or dissection of the aorta. Having refined and reformulated their hypotheses, the clinician continues gathering data in an iterative process.

If, on the other hand, a medical scripts approach is taken, the clinician may recognize the pain as being typical ischaemic chest pain, suggesting acute myocardial infarction. Although there is not a lot of backward chaining, as occurs with the hypothetico-deductive approach, further clinical information is gathered to confirm the diagnosis and exclude other causes of chest pain. This would include serum Troponin, and electrocardiograph to confirm the diagnosis, as well as a chest X-ray to exclude a widened mediastinum, that might be seen as a result of aortic dissection.

In both hypothetico-deductive and illness scripts approach, a hypothesis or diagnosis is formed, further information is obtained to support or refute the hypothesis or diagnosis, and at some point, a decision is made that there is sufficient information to institute a particular course of management in preference to other available options. This model can be used for a single consultation or a series of consultations with a number of management cycles.

In terms of multiple consultations, the first consultation will generally be much longer than subsequent consultations, as the first consultation is used to formulate the initial diagnostic hypotheses, and typically involves a lot of history taking, physical examination, and ordering of investigations. This first consultation also orients the clinician to the social and medical context of the patient. Subsequent consultations are targeted at reviewing the response to treatment and looking for side-effects, as well as checking for complications based on knowledge of the natural history of the disease process. In general, this will take less time than is required for the first consultation. Nevertheless, despite the different focus of each consultation, the process is the same. That is, data are gathered and hypotheses generated, which in turn may lead to medical decision-making and management, or further data gathering.

With the above model, one then needs to consider how each of the various processes can be used as a source of reflection. Firstly, hypothesis generation is itself a reflective process, in that the leaner needs to reflect on what they know of the patient, and what potential conditions may cause the observed symptoms and signs. At a deeper level, the learner may reflect on how the patient responded to their enquiries, as a clue to the underlying pathophysiology. For example, anger expressed by the patient may be an indication of underlying fear that needs to be addressed.

Having developed a set of hypotheses, the clinician can then reflect on whether there is sufficient data, and whether the data supports or refutes existing hypotheses, or whether it leads to new hypotheses regarding the patient (*reflection-in-action*). If the decision is made that there is insufficient data, further data gathering can be undertaken (see decision diamond in Figure 1).

The clinician can then reflect on the appropriateness of this data-gathering (top right box), as well as how this process relates to the hypotheses that have been generated (arrow from left box to right box). That is, how have the questions, examinations, and investigations contributed to their hypotheses? Are their more effective ways of eliciting the information they desired? Has the way they have asked their questions inhibited or directed the patient's response? How much weight have they given each of these responses when formulating their hypotheses? These are examples of reflection on reflection, which leads to the best learning (Schön, 1987).

If the clinician decides there is sufficient data to proceed with management, they can then reflect on such things as what the various management issues are for the patient, how these can be best addressed, whether they have sufficient knowledge about best management practices (*reflection-in-action*, and *reflection-on-action*), and even such things as whether their own cultural or emotional biases are impacting on their management decisions (*reflection-for-action*) (see bottom left grey box).

Finally, having instituted various treatments and observed the patient's response, the practitioner can again reflect on their management strategies, or such things as the natural history of the disease processes, and how these have influenced the patient's outcome (see bottom right grey box). This in turn may lead to further research and learning.

From the descriptions above, it can be seen that a whole layer of reflection can be developed and overlaid upon the consultation processes.

1.5 Contributions

With the above foundation, this thesis describes work undertaken to develop a learning environment, called SIMPRAC, that engages practitioners and students in an authentic activity, and supports a reflective learning process. The authentic activity has been based around the diagnosis and management of a virtual patient. The contributions of this project include:

1. The development of a model for reflection that overlays the consultation process.
2. Development of SIMPRAC, a medical consultation environment for the diagnosis and management of chronic disorders that:
    - Evolve over a series of consultations.
    - Include multiple pathways.

3. Development of a learning environment that supports multiple points of reflection through:
    - The maintenance of a user model that is actively reviewed by the user, and enables the user to compare their approach with that of an expert or with their peer group.
    - Iterative user hypothesis generation and refinement during diagnosis.
    - Feedback based on patient outcome, in response to management decisions made by the user.

1.6 Thesis Structure

Chapter Two reviews literature which has informed the design of SIMPRAC. Chapter Three provides a description of the web-based virtual patient application from a user's perspective. This includes overviews of both the user-patient interaction elements, and case review elements. Chapter Four describes the system architecture and includes details on the user model, and the disease model for multiple consultations. This chapter also describes the architecture for the question and answer interface used by the user during patient interactions. Chapters Five and Six describe the results of three user evaluation cycles, used to inform development. A discussion of the results achieved to date can be found in Chapter Seven. Finally, some conclusions are drawn, and suggestions for further work are made in Chapter Eight.