USING A COGNITIVE MODEL TO SUPPORT THE DESIGN OF TRAINING COURSES FOR PHYSICAL TASKS FOR ENHANCED KNOWLEDGE TRANSFER: THE CASE OF MANUAL HANDLING TRAINING

by

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ABSTRACT

The experience of Low Back Pain (LBP) is associated with the manual handling of loads. The purpose of training workers to handle loads is to reduce the incidence of handling-related LBP. Training will only be effective if workers transfer taught knowledge from the training situation to the workplace. This thesis is concerned with demonstrating support to the process of designing an effective training programme, such that transfer is improved.

To identify the scope of the problem, the effectiveness of a specific training programme was investigated. Physiotherapy students' compliance with training in classroom and workplace settings was compared. Comparison of students' behaviours in the workplace with those of experts revealed deficiencies in some of the students' cognitive behaviours, including their ability to plan their lifting manoeuvres. The data provided the basis for the development of a cognitive model of planning and control - the model of multiple activity control - patient-handling (MMAC-PH) - to support reasoning about enhancements to the training programme such that performance might be improved.

The use of the model to support reasoning about possible enhancements to the training programme is explained. From the model's prescriptions, the development of a training programme enhanced by the addition of cognitive training is described. The enhanced training programme was empirically tested in two contexts, by comparing it to the addition of physical training. The first context was that of subjects without a recent previous experience of LBP, whereas the second, more general context, was that of subjects with recent experience of LBP. The results suggested that the model was effective in supporting the prescription of enhancements to the training programme which improve transfer. However, in terms of the differential effects of the prescriptions the findings are not entirely consistent with the model's predictions. Specifically, performance was unexpectedly enhanced with additional physical training. Possible explanations for inconsistencies are offered.

The research offers support for the use of model-based reasoning to support the design of training programmes for physical tasks in order to reduce the problem of poor transfer. The main qualification relates to the granularity of the model in terms of its ability to completely discriminate between interventions.
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Chapter 1

INTRODUCTION

1.1 Chapter overview

This chapter begins to identify, by means of an example, the general problem which this thesis addresses. Hence, it notes that health care workers required to perform patient-handling tasks are prone to work-related low back pain (LBP), despite undergoing training in patient-handling. It suggests that it is difficult to design effective training programmes for patient-handling tasks, and places this problem in the wider context of the problem of designing training programmes for physical tasks in general. The chapter considers possible ways of solving the problem and locates it within the context of ergonomics. The logic of the thesis is explained and the chapter concludes with an overview of how the thesis is organised in its address of the problem.

1.2 The specific problem

Patient-handling is the most common source of the large number of reported injuries in health service workers. In 1990/1991, 55% of injuries lasting more than three days were attributed to manual handling (Health and Safety Executive, 1992). One of the earliest large-scale studies in the United Kingdom (n = 3912) was by Stubbs, Buckle, Hudson, Rivers, and Worthington (1983a) who estimated that annually, 764,000 days of work were lost by nurses because of back pain. They also found that one in six nurses attributed the onset of pain to patient-handling activities. Ten years later McGuire and Dewar (1993)
Chapter 1: Introduction

reported that about a third of nurses (n = 5184) sustained an injury at work related to moving and handling. According to a relatively recent survey published by the Royal College of Nursing, the National Health Service's estimated bill for replacing trained nurses who leave nursing due to back injury, and for lost nursing hours through sickness is £120 million (Simon, 1992). The consensus is that most of the work-related LBP in nurses is the result of, or is precipitated by, frequent manual lifting of patients (Dehlin, Hedenrud and Horal, 1976; Bell, Dalgity, Fennel and Aitken, 1979; Klaber-Moffett, Hughes and Griffiths, 1993). For a more recent review of the epidemiological data concerning LBP in nurses see Pheasant and Stubbs (1992).

Most of the published work relates to injuries sustained by nurses or carers and indicates that the risk of injury is related to the nature of the handling environment. For example, nurses working in intensive care, acute orthopaedic, community, and geriatric areas are more at risk than those in other clinical areas (Venning, Walter and Stitt, 1987; Knibbe and Friele, 1996), as are nurses required to perform a large amount of patient-handling (Smedley, Egger, Cooper and Coggon, 1995).

In the health care setting a variety of personnel including, for example, physiotherapists, are required to manually handle patients. Hignett (1994) and Blamire (1995) argue that, in contrast to a requirement to move a patient from a to b, a physiotherapist must facilitate a patient's own ability to move more independently. Thus, the therapist is potentially placed at greater risk of injury than other staff members. Williams' (1986) assertion that,
'Physiotherapy is Handling' necessitates that therapists are trained to handle patients in a way which reduces the risk of injury to themselves and to the patient. A question raised is: 'Do physiotherapists experience work-related LBP, or are they protected by their training in patient-handling?'.

The response to this question currently rests on three relatively small-scale studies and one larger study, which have shown that physiotherapists do experience work-related LBP (Molumphy, Unger, Jensen and Lopopolo, 1985; Scholey and Hair, 1989; Chartered Society of Physiotherapy, 1994; van Doorn, 1995). In a study of Californian physical therapists (Molumphy et al, 1985), 29% of therapists (n = 337) reported work-related LBP that persisted for at least three days. Initial episodes of back pain were most frequent among physical therapists under the age of 30. Of the initial episodes, 58% occurred during the four years after qualification, a similar finding to that reported in newly qualified nurses (Cust, Pearson and Mair, 1972; Stubbs et al, 1983a). Eighty-three percent of those who reported LBP were treating or handling a patient at the time of injury and, as in nurses, the incidence of LBP was highest in acute care and rehabilitation settings.

A later, British study used a retrospective, self-administered questionnaire to investigate the pattern of LBP in 249 physiotherapists (Scholey and Hair, 1989). Although 91% of the therapists in this study had been involved with back care education for patients and other staff, they showed a similar pattern of primary and recurrent back pain to an untrained control group. Furthermore, the factors associated with the onset of back pain
and the nature of work environments are similar in nurses and therapists. Thus, both groups are vulnerable when they first encounter a new environment or when they return having been absent for some time (Cust et al, 1972; Molumphy et al, 1985).

The most recent study of physiotherapists (n = 242) (van Doorn, 1995) compared their experience of low back disability with that of dentists and veterinarians. Using data obtained from the records of claims made to a Dutch private insurer for low back disability, both veterinarians and physiotherapists were found to have a significantly greater risk of experiencing disability than dentists.

In a large (n = 1603) survey conducted by the Chartered Society of Physiotherapy (CSP, 1994), more than half of all respondents experienced LBP and 40% of those under the age of 28 reported LBP. Sixty-seven percent of physiotherapists experienced their first incidence at work even though more than 85% of therapists had received training in patient-handling, and 75% believed that they practised what they were taught. Although this was not a rigorously designed investigation, the findings suggest that work-related LBP in physiotherapists may be an even more substantial problem than was previously thought.

Increasingly, the risk posed by manual handling and the need for effective measures to reduce the likelihood of manual handling injuries is being reflected in increased legislation. Section 2 of the Health and Safety at Work Act (1974) and Regulations 8 and 11 of the
Management of Health and Safety at Work Regulations 1992, require employers to provide employees with health and safety information and training. This should be supplemented, as necessary, with more specific information and training in manual handling injury risks and prevention, as part of the steps to reduce risk required by Regulation 4(1)(b)(ii) of the Manual Handling Operations Regulations (1992). This regulation implements the European Directive 90/269/EEC on the manual handling of loads. The escalating number of legal cases (e.g. Fitzsimmons v Northumberland Health Authority, 1989) reflects the size of the problem, and the increasing financial costs to employers if they ignore their responsibility for providing adequate preventive measures, so far as is reasonably practicable.

Although the legislative requirements exist in the context of the requirement to develop a safe system of work, they acknowledge the important role that effective training may have in reducing the risk of injury. A traditional and contemporary response to the problem of work-related LBP has been to provide training programmes in manual handling. These programmes aim to produce in the worker a set of behaviours designed to decrease the likelihood of handling injuries, and hence reduce the likelihood of the complaint of LBP. However, substantial evidence (Snook, Campanelli and Hart, 1978; Wood, 1987; St Vincent and Tellier, 1989) suggests that training programmes fail to achieve their goal. This may, in part, be attributed to workers poor compliance with taught procedures. In turn, this may reflect workers difficulty in applying their training in the non-taught environment, perhaps indicating that they experience problems in
transferring their training. This view is partially endorsed by McGuire and Dewar's (1993) finding that, '35% of respondents did not find the training adequate to meet their needs'. Yet, given the substantial financial costs associated with the provision of training and with its failure, it becomes clear that in a situation such as the National Health Service (NHS) in the mid 1990's, where financial resources are tightly constrained, training must be effective.

To summarise, a significant operational problem for the NHS is the ineffective design of patient-handling training programmes for health service workers. The problem is evidenced generally, by the poor outcome of such programmes with respect to their stated goal of supporting a set of worker behaviours designed to decrease injuries and the complaint of LBP. More specifically, the problem is evidenced by workers' poor compliance with taught procedures. Physiotherapists exemplify an occupational group in which this problem is manifested.

1.3 A General Problem - Training programmes for physical tasks

In many ways the problem of designing effective training to support the performance of manual handling tasks in, for example, the work of physiotherapists, is a subset of a more general problem: designing effective training for tasks which are, at face value, physical. For example, many authors have reported the difficulties which affect the design of training for sporting tasks (Christina and Corcos, 1988; Martens, 1990). But, why is the
design of training programmes to support physical tasks difficult? As a first response to this question, it is necessary to recognise that human performance is supported by the mental and physical behaviours of a person (Dowell and Long, 1989). Mental behaviours are those concerned with the acquisition, storage and transformation of knowledge, and include, for example, planning and reasoning behaviours. The effect of training will depend on its impact on the mental and physical behaviours and upon their relationship as a subject performs a task. Therefore, designing manual handling training programmes to support transfer may involve either reconfiguring those components of the programme concerned with the physical aspects of the tasks, or those concerned with the mental aspects, or both.

In general terms, tasks are classified mainly at face value. Tasks with a predominance of observable elements are classified as physical tasks, whereas tasks with mainly problem solving or decision making components are classified as cognitive (Fleishman and Quaintance, 1984). One significant limitation of such intuitive task description is the dual tendency for training to be designed via virtual exclusive harness to a specific discipline, or via haphazard use of a multidisciplinary perspective. Currently, the unilateral approach to task categorisation is reflected in training. Hence, training programmes designed to support essentially physical tasks tend to emphasise a very predominantly biomechanical or physiological perspective. Consequently, few attempts have been made within the design of training programmes to either make explicit the required mental behaviours, or to consider the relationship between the physical and mental behaviours.
This thesis is concerned with the specific problem that taught skills may not be transferred from the taught to the non-taught situation. Improving transfer may involve identifying and developing ways of supporting the interacting mental and physical behaviours trained, to produce enhanced performance. Thus, the general research problem to be addressed is that of supporting the design of more effective training for tasks which, at face value, might be classified as predominantly physical, for example, the manual handling of loads. This can be contrasted with supporting the design of more effective training for tasks which appear to be predominantly cognitive, for example, air-traffic control.

1.4 Identifying a solution

Training programmes in manual handling need to support performance in diverse situations which impose variable physical and psychological demands. As ergonomics is an applied discipline which aims to reduce any mismatch between a person's capabilities and the demands of the task, environment or organisation, it may provide the basis for a solution to the problem. However, other approaches to solving the problem exist and warrant discussion.

One possibility is to design training programmes on an ad hoc basis. Yet, as previously mentioned the current tendency is for training to be designed by ad hoc adoption of a multidisciplinary approach, so this seems unlikely to be helpful in identifying a solution to the present problem. For example, ad hoc practice might be reflected in the, 'quick and
dirty' addition of extra physical practice. However, this is costly in terms of training time. There may also be costs associated with exposing the trainees to more risk of injury within the training environment. The central concern of manual handling training programmes is to reduce the likelihood of work-related LBP. Yet, given the high prevalence of LBP in the general population, it is possible that trainees may have some level of back pain making unwise the haphazard addition of potentially injurious movements, via the, 'quick and dirty' addition of physical practice.

An alternative, more radical solution to the problem, might be to focus on the person performing a manual handling task, and aim to enhance the training programme's effectiveness by achieving a better match between it and its recipients. This is effectively the rational basis of selection, which aims to prospectively identify individuals who would be at particular risk, and to exclude them from work, and hence training, involving manual handling tasks. Theoretically, this approach could be extended such that individuals at greater risk could be offered more extensive training. However, this begs the question: 'In what way would the training be more extensive?' Furthermore, the efficacy of such an approach is constrained by the fact that, despite the identification of risk factors such as general unfitness (Cady, Bischoff, O'Connell, Thomas, Allan, 1979) or a history of LBP (Biering-Sorensen, 1984), personal risk factors have been found to have a poor predictive ability. Hence, it is unsurprising that the most extensive study of selection found no significant differences in back injury rate between industrial organisations which operated selection programmes, and those that did not (Snook et al, 1978).
Assuming that appropriately reliable predictors could be found and used satisfactorily, the selection approach may reduce the back injury rate. It may also identify individuals who are more physically able to use their training so that they comply with the taught procedures. However, this will only affect transfer to the extent that the problem arises from the physical incompatibility of a person with the task. More pragmatically, given the proportion of the population who may be required to care for and hence handle patients, reliance on selection seems unrealistic.

A third possible approach to the problem might be to change the nature of the organisational system within which work occurs. This could be effected in several ways. For example, improvements in staffing levels may facilitate the transfer of learned skills to the extent that lack of human resources contributes to the problem. Similarly, the provision and use of sufficient, appropriate, equipment may render training more effective when transfer is constrained by equipment-related concerns.

Each of the approaches considered in this section focuses on a different part of the problem. As such, their potential to reduce the overall problem is restricted by the extent to which it arises from the aspect of the problem addressed by the particular approach. To increase the potential to solve the problem, what is needed is an approach which can consider the problem in a more global manner.
1.5 The Ergonomics context

In seeking a more global address to the problem posed:

*How can more effective training programmes in manual handling be designed?*

the relationship of the problem to the discipline of ergonomics merits consideration.

The central concern of ergonomics is the improvement of a person's performance of a task by optimisation of the human machine system which is performing the work. It is this concern which distinguishes a training programme designed with respect to ergonomics from one designed with respect to other disciplines. Thus, ergonomics includes an orientation to the task and to performance, and, more specifically, to the problems of task performance generated by ineffective training programmes.

In seeking optimisation via a global systems-oriented view, ergonomics may recruit cross-disciplinary knowledge to the design of training programmes. Thus, it has the potential to bring physical and psychological approaches together in an explicit manner. This can be contrasted with the implicitness afforded by ad hoc practice.

In summary, an ergonomic approach provides a means of addressing the research problem in order to enhance training in several ways. It provides a body of multidisciplinary
knowledge, has a task and performance orientation, and offers a systems-based view of the problem. The combination of these is what makes the ergonomic approach to the problem presented in this thesis a novel one.

1.6 Logic of thesis

Given the choice of domain, the particular problem to be addressed is: how can ergonomics support the more effective design of training programmes in patient-handling? The thesis explores one answer to the question:

that ergonomics can contribute by providing a model of a human performer that can be used by course developers to increase the effectiveness of a training programme's structure.

The use of an ergonomic approach in the present work is aimed at identifying an enhancement to a training programme. The enhancement aims to improve a person's ability to apply taught material in novel situations, by providing them with knowledge to support them in such situations. The work aims to acquire new knowledge concerned with the failure of trainees to implement learned skills in non-classroom contexts. This failure is assumed to be attributable to the fact that trainees have not acquired appropriate cognitive structures able to support the transfer of patient-handling skills from the classroom to the workplace.

Relating training techniques to the knowledge required is central to course design, thus
the enhancement seeks to provide the knowledge required to support improved performance. Therefore, the key technical issue to be addressed is the conceptualisation, operationalisation, and application of an improved set of cognitive structures which is not currently available to trainees. The present work provides a framework for reasoning about the techniques which might be used to enhance training to support transfer. In so doing, it aims to acquire and provide programme designers with knowledge, which, when added to the programme, supports the transfer of patient-handling skills to new contexts. The knowledge needs to have an adequate scope and appropriate level of description, in order to support the programme designer's reasoning about the specification of support to the behaviours required for the performance of patient-handling tasks.

To summarise, in this thesis, the ergonomic approach is applied to the specific problem of ineffective training to support patient-handling tasks. The work aims to support the specification of a solution to the problem via an enhanced training programme, based on an analysis of the cognitive behaviours which will support effective physical performance. Empirical testing is central to an ergonomic approach, so the effectiveness of the solution is tested experimentally in the context of two groups of trainees. The two groups are first, therapists with no previous experience of LBP and second, therapists with a history of LBP. These two groups, although related, are distinguishable by the context in which training occurs.
Chapter 1: Introduction

1.7 Organisation of thesis

The question of how ergonomics can support the ineffective design of training programmes in patient-handling can be broken down into three subquestions:

1. How can the weaknesses of a current generic training programme be established in order to provide a basis for redesign?

2. How can the behaviours of people engaged in patient-handling be modelled?

3. How can the model be applied to help develop enhanced training programmes?

QUESTION 1 will be addressed in Chapters 2 and 3. Chapter 2 uses a review of the literature to expose the problem, Chapter 3 describes an exploratory study aimed at confirming the existence and nature of the problem, and attempting to understand its causes in terms of training design.

QUESTION 2 is the concern of Chapter 4 which describes the general and specific requirements of a solution. It provides information relevant to interpreting the findings of Study 1, and reviews the training literature in order to specify the possible solution space. It considers a framework for the problem and the requirements of an explicit model. Details of the model appear in Chapter 5.
Chapter 1: Introduction

QUESTION 3 is addressed in the remainder of the thesis. Chapter 6 describes the development of a solution to the problem. Chapter 7 describes an experiment to test the enhanced programme and hence the model and Chapter 8 describes a generalisation of the solution by considering the case of training for trainees with a recent experience of LBP. The thesis concludes with an assessment of the work in Chapter 9.

1.8 Summary

In conclusion, this thesis will investigate the extent to which training can be designed to enhance transfer. The overall aim is to support reasoning about training people to transfer their training in patient-handling tasks from the teaching to non-teaching environments. A necessary first step is to explore the nature and existence of the problem suggested in this chapter.
Chapter 2
THE PATIENT-HANDLING TRAINING PROBLEM

2.1 Chapter overview
This chapter extends the problem specification by introducing manual handling training and clarifying its relationship to training in patient-handling. The chapter begins with consideration of the scope of patient-handling. The review that follows aims to provide a context for the work presented in the remainder of the thesis. The intention is to provide the reader with only sufficient technical information to appreciate the role and function of patient-handling training as addressed in this thesis.

2.2 Patient-handling training
This section is essentially a thumbnail sketch of patient-handling training, considering what it is and the context of its use.

2.2.1 Manual Handling and Patient-Handling
Manual handling operations are defined according to The Manual Handling Operations Regulations (1992) as:

'any transporting or supporting of a load (including the lifting, putting down, pushing, pulling, carrying or moving thereof) by hand or by bodily force'

Thus the definition includes both transporting a load and supporting a load in a static
Chapter 2: The Patient-handling problem

posture. A subset of manual handling is the handling carried out in health workplaces. Much of this entails handling human beings as patients, i.e. patient-handling. Informally, patient-handling can be characterised as lifting a patient, moving a patient's body part, assisting a patient to walk, rolling a patient, transferring a patient from a bed to a chair or vice versa, positioning a patient, or assisting a patient to retain balance. Handling tasks may involve the use of an aid(e) such as a hoist, or assistance provided by another person(s). Regarding the patient, an assisted manoeuvre is one in which the patient takes some of his own weight and contributes, somewhat, to the movement.

The dependency and mobility problems of patients will vary according to the specific health workplace. Carlson (1989) showed that health personnel are often required to move or to assist to move patients, whose weights range from 37kg to over 100kg. Furthermore, in patient-handling, the load is an awkward shape and patients can be combative, heavily contracted, uncooperative, and unpredictable. They may suddenly resist movement and/or grab personnel, throwing them off balance (Carlson, 1989). These considerations coexist with the spatial limitations imposed by many health workplaces.

Hence, it is unsurprising that the activity of handling patients has a close relationship with episodes of LBP. Of all patient-handling incidences leading to back pain, Stubbs, Rivers, Hudson and Worringham (1981) attribute 41.3% to, 'lifting or moving a patient up the bed'. The high frequency of transferring a patient up the bed was also identified in a large-scale study by Bell et al (1979), with the frequency of the task increasing the probability of injury.
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Since 'lifting' of loads is associated with the largest portion of all back injuries, training in 'safe' lifting procedures has been advocated and conducted for decades. The overall aim of most training programmes in manual handling, is to reduce the incidence of work-related LBP, by helping workers to develop a set of behaviours that will reduce the likelihood of back pain. Whereas many training programmes have focused on supporting the acquisition of patient-handling skills (Raistrick, 1981; Troup and Rauhala, 1987), other programmes have concentrated on improving a person's physical capacity to manually handle, by improving trunk strength and fitness (Genaidy, 1991). As the latter are less numerous, presumably because they are likely to be more costly to run, the definition of manual handling training programmes used in this work excludes programmes where the emphasis is on the strengthening of muscles or the enhancement of cardiovascular fitness.

No studies have been presented which convincingly show that a particular lifting technique is better than another. This is reflected in a lack of consensus on the details of correct patient-handling techniques (Parnianpour, Bejjani, Pavlidis, 1987; Garg, 1990). Similarly, experts are not in complete agreement concerning which procedures are best for specific patient transfers (Venning, 1988). However, there is reasonable agreement concerning the very broad principles supporting safe movement, (Troup and Edwards, 1985), and this makes any consideration of training effectiveness less problematic. The next section briefly considers the content of training programmes. This is followed by a review of the evidence concerning the effectiveness of patient-handling training programmes in section 2.4.
2.3 Content of training programmes

This section aims to briefly report the views and recommendations of arbitrarily defined experts representing a variety of perspectives on patient-handling training. The aim is to provide sufficient background information concerning recommended practice to provide a yardstick against which to judge the representativeness of the programme investigated in this thesis.

Troup and Edwards (1985) in their literature review on manual handling, summarise those aspects of the training curriculum that are 'generally agreed'. These include:

- the dangers of careless and unskilled handling methods
- levers and the laws of motion
- anatomy of the vertebral column
- effects on the body of lifting, pulling, pushing
- the components of skill:

  preparation
  keeping the load close to the body
  avoiding twisting and sideways bending
  use of legs and of body weight
  proper hold and foot position
  straight back

Similar principles are reiterated in the recommendations of both the Chartered Society of Physiotherapy (1993) and the Health and Safety Executive (HSE, 1992) concerning training. The HSE emphasise the need for training to be tailored to the particular handling
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tasks likely to be undertaken, and reiterate the following principles:

- stop and think: planning the lift, removing obstructions and assessing the need for help
- place the feet: balanced and stable base
- adopt a good posture
- get a firm grip
- lift smoothly, do not jerk
- move the feet
- keep close to the load
- put down, then adjust

The HSE also emphasises that training should incorporate practice and that the training conditions should be as similar as possible to the workplace conditions.

One of the most recent collections of experts' views on manual handling training is incorporated into the Interprofessional Curriculum which is based on the recommendations of a Multidisciplinary Working Group for Safe Handling (National Back Exchange, 1995). This group comprised representatives of five organisations, namely, the Ergonomics Society, The College of Occupational Therapists, The Royal College of Nursing, The Chartered Society of Physiotherapy, and Back Exchange. Reflecting the need for more trainers, this group have produced a programme to train back care advisers within the Health Service. The programme comprises four modules entitled: i) health, ii) ergonomics, iii) patient assessment and handling, and iv) social organisation. Examples of the programme's contents include:
- Assessment of patient and task with respect to potential manual handling risk
- Manual holds
- Manoeuvres for moving the patient in bed
- Assisting walking
- Moving from lying to sitting; sitting to standing
- Transfers: bed to chair
- Hoists
- Legal requirements

The recommendations comprehensively address issues concerning the content of training programmes but are less explicit regarding ways of configuring such programmes.

2.4 The effectiveness of patient-handling training

A systematic search of the literature was undertaken. The MEDLINE, NIOSH, HSE, and PSYCHLITT electronic databases were searched for the ten years before December 1995 for articles in which patient-handling and training were major areas of focus. Other sources of articles included references of articles found by the aforementioned methods, a manual search of the printed ERGONOMICS ABSTRACTS from January 1985 to June 1996 and personal communication.

To be included in this part of the review, studies had to meet the following criteria:

- The patient-handling training programme should come under the definition in section

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2.2.1, hence the exclusion of studies with a purely 'physical fitness' emphasis

- at least brief details of the essential nature of the training programme should be clearly reported

- the programme should be applicable to health care workers, (given the paucity of data specifically concerning physiotherapists, restricting consideration to studies involving physiotherapists only was not feasible)

- the methodology should be clearly reported and replicable

- original study results had to be presented

- the article had to be published in English

The purpose of these criteria is to restrict consideration to studies that are relevant to the operational problem and likely to be reliable. Abstracts and unpublished studies were excluded. Since direct comparison between the separate studies is impossible, as each examined a different population, considered particular aspects of the problem, and had its own methodology for assessing the extent of the problem, the studies will be considered in order of methodology. Classroom-based studies will be considered first, followed by studies based on field observations, and concluding with studies with an epidemiological emphasis. The principal methods and findings of each will be reported. A summary and
2.4.1 Classroom-based studies

A considerable amount of published work exists concerning patient-handling training in nurses (Takala and Kukkonen, 1987; Wood, 1987; Videman, Rauhala, Lindstrom, Cedercreutz, Kamppi, Tola and Troup, 1989), and there are several epidemiological studies concerning LBP in physiotherapists (Molumphy et al, 1985; Scholey and Hair, 1989; van Doorn, 1995). However, the author has been unsuccessful in identifying any published work which specifically investigates the effectiveness of training in physiotherapists.

In a preliminary study, Ellis (1993) used a postal questionnaire to explore the reported characteristics of training programmes offered to undergraduate physiotherapists (n = 85) in eleven, randomly selected educational institutions. From the reported raw data the mean programme length can be calculated to be 3.68 hours (sd = 0.6), representing a combination of theory-based sessions (mean = 1.90+/-0.2 hours) and practical sessions (mean = 1.77+/-0.52 hours). However, neither the temporal organisation of the programmes, nor the teaching methods used are reported.

The topics covered by the programmes were summarised although unfortunately, the reported categories lack clear definition possibly explaining some apparent idiosyncrasies. For example, 'back care/ergonomic approach' comprised one category, reportedly addressed by eleven institutions, yet only three institutions reported including
biomechanics of the spine, and there is no mention in any of the categories of spinal anatomy. Nevertheless, all courses taught the classical principles of lifting, i.e. stance, grip and commands as stated by Hollis (1985) and Lloyd, Tarling, Troup and Wright (1987). Students' perceptions of the effectiveness of training were assessed on a five-point scale, and indicated that 71% felt that they had been taught only the, 'basic principles with room for improvement'. The suggested improvements included reduced class size and increased practice time. Although, this was a small, exploratory study, given that 27% of the subjects had already experienced LBP related to patient-handling, it seems clear that methods of supporting more effective training warrant further consideration.

Troup and Rauhala (1987) assessed the patient-handling skills acquired by particularly trained (n = 106) nurses and by a control group (n = 93). The latter underwent 'traditional' training in patient-handling, whereas the former underwent a programme involving 20 hours of theory and practice in semester one, followed by five hours of predominantly revision material in the four subsequent semesters. The programme was specially designed and emphasised problem-solving skills in the context of biomechanics and ergonomics.

Assessment of subjects required them to perform two patient transfers under standardised physical conditions in which subjects were told the patient's, 'medical condition'. The performances were videoed and subsequently assessed by two observers. The assessment considered the manoeuvres in three stages, namely, preparations for the lift, the actual lift, and completion of the lift. A single measure of performance was made on a 0-3 scale defined as follows:
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0 - 'bad' - wrong technique, use of dead lift, twisted back or excessive load on spine

1 - 'poor' - imperfections at different stages, back unnecessarily loaded but probably not dangerously so

2 - 'good' - stages of lift well planned, back not excessively loaded, but timing did not work out satisfactorily

3 - 'excellent' - right technique and smooth correct lift

Although, on average, subjects in both groups scored less than half marks, the results showed that the experimental group scored significantly better than the group that had undergone 'traditional' training. However, it is difficult to comment on the validity of these findings in the absence of details concerning the nature of the traditional training. Furthermore, the authors acknowledge that the results may not reflect subjects' actual working practices. Subsequently, Videman, Nurminen, Cedercruetz, Asp, Rauhala and Troup (1986) followed up the untrained control group. They found that in the year following assessment of handling skill, 11 out of 86 nurses had a back injury and all these subjects had scored less than 0.5 when assessed.

The work of Troup and Rauhala (1987) also provided the foundation for a later study aimed at evaluating the effect of training on patient-handling skills (Videman et al, 1989). Again, two groups of nursing subjects were investigated, a control, 'traditionally' trained group and a group trained according to the same programme previously described.
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Videorecordings were made as each subject performed two transfers on a 'model' patient. Performance was assessed using a scale similar to that used in the previous study, but unlike in the previous study, the 0-3 scale had seven points, incremented at 0.5 intervals. Presumably, this allowed more sensitive data collection, although the validity and reliability of this assessment are not clearly reported. The results indicated relatively poor patient-handling skills in both the trained (mean = 1.31 +/- 0.77), and the control (mean = 0.50 +/-0.55) groups. The trained group's scores were, however, significantly higher than those of the control group, indicating that the lifting skills can be acquired. However, the only statistical difference between the groups was in the incidence of acute back pain occurring in the workplace which was significantly lower in the skilled nurses. There was no difference between the groups for other forms of back pain. Furthermore, when data relating to the incidence of acute pain is pooled with that relating to other forms of pain, no significant between-group difference is found. Videman et al (1989) conclude that suitable training may be rendered ineffective by ergonomically unsatisfactory environments. What remains uncertain is the extent to which the ineffectiveness of training can be attributed to such environments.

2.4.2 Field studies

One of the earliest programmes to be evaluated in the field was that introduced by Raistrick (1981), which provided training for two thousand employees of a District Health Authority (DHA). When first reported, the programme had been operating for about a year and the number of back injuries incurred while lifting patients appeared to be falling.
Meanwhile, Wright surveyed the need for training in patient-handling and developed a programme for another DHA of comparable size (Wright, 1981a, b). Following an introductory course held over two days, 38 trainers held a series of short training sessions for small groups over a period of six months. A substantial initial fall in the back injury rate (Daws, 1981) was not sustained the following year. As Troup and Edwards (1985) point out, these findings may have been due to an early Hawthorne effect or else to a change in standards for reporting injuries. Whatever the explanation the findings underline the need for training effectiveness to be considered via controlled epidemiological studies.

Prior to conducting a field study involving 32 orderlies working in a geriatric hospital, St Vincent and Tellier (1989) formed the view that, 'this (training) preventive approach would probably be effective if it could be improved'. The study aimed to identify the main deficiencies of training programmes by investigating whether the methods taught were used and characterising the deviations from the taught methods. It is claimed that the twelve hours of theoretical and practical training represented the teaching of the basic principles characterising the, 'bent knees, straight back' profile.

Direct field observations were made using an observational grid in which, the main parameters were assessed subjectively on a descriptive three-point scale. For example, in relation to the criteria of back posture, the judgments were: back straight, somewhat bent, or very bent. The other parameters included assessment of, 'holds', foot, knee, and back positions, direction of effort, and weight transfer. Except for angular foot position, assessment of these parameters was satisfactory in terms of intra-observer reliability (91%
agreement), inter-observer reliability (89% agreement) and accuracy (91% agreement).

The results showed that the handling principles taught were infrequently used in the workplace, and that this was especially so in horizontal as contrasted with vertical handling operations. St Vincent and Tellier (1989) defined the assessed criteria in absolute terms, rather than in relation to what was possible in the particular circumstances. Hence, a possible explanation for the results obtained is that the physical constraints of the environment prevented the principles taught from being applied. A similar explanation can be applied to other studies that have found that taught principles are seldom used (Hale and Mason, 1986; Wachs and Parker, 1987). The implication is that clearer assessment is required of the effectiveness of training as contrasted with assessment of the use of taught principles per se. There are several ways of approaching this. For example, assessments could be made of students' performances within ergonomically optimised environments. An alternative approach would be to desist from separating subjects' performances from the environment in which they occur. This might lead to assessment based on subjects' use of taught principles making allowance for the constraints present.

The study by Takala and Kukkonen (1987) should not strictly be considered here as it fails to meet the criterion above relating to clear description of the training programme. However, it will be discussed as its methodology is clear, it has some interesting findings, and is often referred to. Workplace analysis, questionnaire, and video analysis were used to study patient lifting in a sample of 143 trained nurses working on seven geriatric wards. The authors found evidence of general non-compliance with taught principles, such that
subjects failed to either use mechanical aids when available, or to adopt an acceptable working posture, leading to the report that:

'bent and twisted trunk positions were recorded.... often in situations where the observer could see no need to work in such an awkward position'

A question raised by St Vincent and Tellier's (1989) study and that of Takala and Kukkonen (1987) is whether the lack of use of taught principles in the workplace represents a failure in respect of retention of the training provided, or else suggests that the original training was, for whatever reason, not adequately acquired.

The work of Wood (1987) partly addresses this question. He evaluated a back injury prevention programme in a group of geriatric hospitals using a before-after comparison and time-series analysis. The back programme centred on training by a physiotherapist. It included individual feedback being given to nursing personnel after 30 minute observations of patient-handling activities. The programme was instituted on two units of a single hospital with a third unit serving as a control.

An interesting finding was that in the baseline assessment which required subjects to perform two handling operations, apparently on a model, 98% performed 'satisfactorily' in an assessment conducted by a physiotherapist. However, the nature of this assessment is unreported. The authors highlight the barrier perceived by subjects between the taught and non-taught environments:
'Generic rules of lifting have not been viewed as being helpful in our hospital situation, staff members would leave a classroom demonstration and say, "Oh sure that technique works when the model is a helpful nurse aide, but what about Mr Smith? He's big, uncooperative and aggressive'"

Subsequently, subjects followed their normal working routine and were shadowed for 30 minutes by a physiotherapist who provided feedback with respect to the subject's handling skill.

The main dependent variable was the number of wage loss claims filed for back injuries arising from patient-handling activities. The results showed no quantitative differences between the groups. However, Wood (1987) reports that staff feedback in terms of course evaluation forms and subjects' comments were more positive. It is unfortunate that more detailed qualitative assessment was not made, forcing the conclusion that individual instruction and feedback on lifting technique is not beneficial.

Referring to the acceptable baseline skill levels of his subjects, Wood (1987) suggests that the results obtained may reflect that these subjects have nothing to gain from further training. This, he suggests, may imply that training should be targeted at those subjects in whom a demonstrable skill deficiency exists. This presumes that firstly, classroom performance and workplace performance have a direct relationship and secondly, that the feedback provided did serve to optimise subjects' compliance with taught principles. In the absence of data on subjects' performances, the latter appears somewhat speculative.
In 1976, in an interview-based study to determine the incidence of spinal symptoms in a population of nursing aides, Dehlin et al found no effect on the incidence of LBP when nursing aides received repeated instruction emphasising the, 'straight back, bent knees' principles of lifting. Subsequently, in a quasi-experimental study, they compared the effect on back pain of three interventions applied to 45 nursing auxiliaries with a history of back problems (Dehlin, Berg, Andersson, and Grimby, 1981). Rather than being randomly allocated to the experimental condition, volunteer subjects were assigned to one of three groups according to the building in which they worked, as follows:

a) aerobic exercise - (n=13): aimed at increasing subjects' physical fitness

b) ergonomic counselling - entailing instruction in lifting and ergonomic principles (n=14): aimed at making subjects, 'more aware of the importance of using the most optimal lifting techniques in different lifting situations'

c) control group - with no training - (n=15)

No statistically significant differences were found between the groups with respect to LBP symptoms. However, both experimental groups showed a trend towards shorter duration episodes of back pain, and the small sample size made a Type 2 statistical error possible. Furthermore, the assumption underlying this study is that changes in training may be reflected in behavioural changes leading to alteration in LBP symptoms. The validity of this assumption seems questionable for two reasons. Firstly, no tests of subjects' knowledge were made. Secondly, the only attempt to determine whether the lifting techniques of subjects in Group b) actually changed was via their reported use of the
'patient lift'. Although precisely what is meant by the term 'patient lift' is unclear, the authors failed to find greater evidence of its use in Group b).

In another observational study, Wachs and Parker (1987) distinguished health-related behaviour (lifting behaviour) from health outcome (pain and injury). They devised a study premised on the notion that describing nurses' actual lifting behaviour would provide evidence for specific preventive strategies. Volunteer female nurses (n = 178) formed part of a convenience sample of four Midwestern community hospitals. An observational checklist comprising 13 dichotomous items was divided into two subscales. The first eight-item scale allowed recording of nurses' postures and movements while the second five-item scale allowed recording of environmental factors. In terms of consistency of the scale items Wachs and Parker (1987) found that the environmental scale was markedly less internally consistent than the posture and movements scale. They suggested that this reflected the fact that in environmental terms one behaviour such as raising the bed was not related to another such as lowering the siderails. Conversely, they suggested that the higher internal consistency for postural items indicated the existence of relationships between the scale items.

In terms of the assessments made using the environmental and postural subscales, 86% and 83% respectively of nurses failed to comply with the requirements as prescribed. Hence, despite concerns relating to the reliability of the observational instrument there was clear evidence of non-compliance. This is further supported by the fact that in terms of the overall scale, only 2% of nurses completed behaviours as prescribed. Wachs and
Parker (1987) conclude by emphasising the need for research to address the primary question of whether students understand what they are taught, as reflected in their cognitive and motor abilities at the end of the training period.

Using a pre and post-test design, Rogers (1987) began to address the question raised by Wachs and Parker (1987). Rogers conducted a field study to evaluate the effect of an experiential lifting programme on subjects' knowledge of lifting procedures and those procedures actually used, in a sample (n = 59) of trained and student nursing staff. Data collection was via interviews and ward-based observations. Rogers (1987) identified a discrepancy between student nurses' knowledge and practice. Although 33-47% of those interviewed mentioned a 'safe' lift as being easier to do and best for the patient, only four out of 66 lifts used by the same subject were observed as being safe. In response to a question concerning which lift would be 'best' for the patient, an equal percentage (31%) named the shoulder lift and an unsafe method of lifting as safest. Rogers does not report the unsafe method of lifting. Even following the experimental lifting programme there were no significant differences in the knowledge of lifts between the experimental and control groups, leading to the inevitable conclusion that training was ineffective.

More recently, Kane and Parahoo (1994) used a 17-item questionnaire to assess the knowledge of, and reported use of lifting techniques recommended by the Royal College of Nurses in 16 undergraduate nurses. They found a substantial discrepancy between students' knowledge and their reported activities. More than 60% of respondents correctly identified the 'drag' lift as being not recommended and yet, reported it as the one
Many authors believe that effective training may be only one component of a back injury prevention programme and have advocated the introduction of an approach based on the redesign of the working environment (Stubbs et al, 1983b; Lloyd et al, 1987; Venning, 1988). Hence, although it is debatable whether the study by Garg and Owen (1992) should be considered here as the training programme was concerned with supporting nursing assistants' use of ergonomically improved hoists, walking belts and shower chairs, it will be considered for two reasons. Firstly, the principles underlying use of the improved aids are, inevitably, similar to those applicable to conventional training. Secondly, consideration of the effectiveness of training applied within a redesigned workspace offers some insight into the extent to which the effectiveness of training can be related to the redesign of the environment.

Garg and Owen (1992) used a pre and post-intervention study to investigate the effectiveness of introducing redesigned hoists walking belts and shower chairs to volunteer nursing assistants (n = 57). Subjects received at least four hours training which included video and practice elements. Direct observations provided data on subjects' use of the aids to indicate their 'acceptability', i.e. subjects' compliance in using them. Other data collected were ratings of perceived exertion and reports of injury.

In relation to injury data, both back injury rates and loss of working time decreased dramatically in the post-intervention phase. However, as the post-intervention phase lasted
less than a year these data should be treated with some caution as similarly positive findings by others (Daws, 1981) have, on longer follow-up, proved more disappointing. The results also indicated high overall 'acceptability' of the ergonomic improvements for patient transfer tasks, but low acceptability for non-transfer tasks in which the subjects had not been trained to use the improvements. In the absence of a control group it is not possible to differentiate the effectiveness of the training from the effects of the improvements themselves. An interesting observation, however, was that the subjects tended to lift the patient when using the walking belt, and this lifting action appeared to be related to most of the injuries associated with use of the walking belt. This led the authors to state that, 'to modify this ingrained behaviour would, it is believed, require extensive education and training of nursing assistants in new skills' (Garg and Owen, 1992).

2.4.3 Epidemiological studies

Many researchers have undertaken epidemiological studies to investigate work-related LBP in health workers and several of these have explored the effectiveness of training with respect to the subsequent risk of experiencing back pain (Dehlin et al, 1976; Stubbs, Buckle, Hudson and Rivers, 1983b; Scholey and Hair, 1989).

Stubbs et al (1983a) point out the paucity of scientific data to support systematic instruction in lifting techniques. They present epidemiological data relating the presence or absence of LBP to the length of time spent in classroom or ward-based instruction in patient-handling. The absence of any association between the point prevalence of back
pain among nurses and the extent of their prior training in lifting techniques, led to the conclusion that there was no evidence to indicate that the amount of training, be it classroom or workplace-based, was relevant to the point prevalence of LBP. Furthermore, in an earlier study conducted by Stubbs' team (Stubbs, Hudson, Rivers, and Worringham, 1980), 32% of nurse respondents had received less than three hours instruction in patient-handling, leading the authors to suggest that questions need to be addressed concerning the design of training to support the ability of students to acquire and retain patient-handling skills.

Similarly, a prospective multicentre cohort study by Venning et al (1987), which involved observation of 4306 nurses, from ten hospitals, for twelve months, suggested that prior training in back care and lifting was not protective during a one year follow-up interval.

In their comparative study of 249 physiotherapists and 236 non-medical workers, Scholey and Hair (1989) found that more than three-quarters of the therapists had received pre-registration training, and 91% were involved in the back care education of others. Despite this, there was no significant difference between the groups in the occurrence of back pain. Physiotherapists were asked to report their satisfaction with the training they had received. This produced an interesting finding, in that although younger (< 30 years) therapists were more satisfied with their training they also, in accordance with Molumphy et al's (1985) findings, experienced more back pain. One possible reason for the discrepancy between satisfaction with training and LBP might be that the training received by the therapists was inadequate in a way which was not discernible to them. This would
be consistent with the finding that older (> 45 years) therapists reported less satisfaction (43% satisfied compared to 78% in younger group) with their training and suggested a need for more clinically-based training. Clearly, further investigation is required to assess the adequacy of the training received by novice therapists and their acquisition and retention of the training material.

### 2.4.4 Summary

It is not difficult to find ways of criticising many of these studies particularly given the deficiencies in experimental design and the inadequate control of training. However, there is a certain consensus among the findings, although the absence of a single coherent picture is not surprising given the variety of approaches taken.

There is considerable evidence that the design of patient-handling training programmes is informal and ad hoc rather than based on a formal analysis of the problem. Therefore, it is hardly surprising, that despite the plethora of training programmes that exist in patient-handling, few have unequivocally demonstrated effectiveness, and fewer still a rational development of a training programme. As Kroemer (1992) points out, fundamental questions concerning which method of training is most effective and how much knowledge is needed remain unanswered.

The multi-faceted nature of the problem has several consequences. One is that the problem cannot be comprehensively specified. This is reflected in the variety of approaches to the problem and the fact that most studies have focused on either classroom, or workplace
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behaviour, but few on both. A second consequence is that whereas many programmes have assessed back pain, to the neglect of whether or not practice is based on what is taught, others have not always addressed patient-handling in the context of LBP.

2.5 Conclusions

In conclusion, despite increasing legislation, the increasing costs to society of LBP and a reasonably large number of research efforts, the following comment from Stubbs et al (1983b) remains as relevant today as when it was issued

'this interest (in manual handling training) has however usually been more conjectural than scientific' and, '...there is no scientific evidence that it is, in fact, effective in reducing the frequency or severity of back pain'

As a preliminary response to this view, the next chapter describes a study which considers the effectiveness of one training programme in more detail.
Chapter 3

STUDY 1: AN OBSERVATIONAL STUDY OF TRANSFER OF TRAINING IN PATIENT-HANDLING

3.1 Chapter overview

This chapter reports an exploratory study which compares novices' performance of patient-handling tasks in the taught, classroom environment to their performance of patient-handling tasks in a workplace environment. Novices' performances in the workplace are compared with those of experts. The investigation reported confirms the inadequacy of training in patient-handling identified in the literature, and considers the problem in relation to the design of training. Details of the methods, results and preliminary conclusions appear in this chapter. The outcome of the study, in the sense of the details of the specific model used as an analytic tool and developed from it, appears in Chapter 5.

3.2 Background to Study 1

3.2.1 Introduction

This study aimed to expose the nature and magnitude of a research problem. It explored the effects of a specific training programme on novice performance of patient-handling tasks. Based on its content and organisation, the training programme investigated was deemed to be reasonably representative of those reported in the literature. The work considers the specific case of students who had undergone the programme and who were required to apply the taught principles in the taught context, i.e. a classroom setting (CR).
and in a different, non-taught context, i.e. a workplace setting (WP). Students' performances in the workplace were compared to those of experts to identify potential areas of improvement.

3.2.2 Aims of study

The specific aims of the study were:

1. To determine whether novices' performances of patient-handling tasks in the classroom setting differ from their performances in the workplace, and from the performances of experts.

2. To identify differences between the behaviours of novices and experts in the workplace.

3. To identify likely reasons for any differences between novices' performances in the two situations.

4. To suggest the preliminary requirements for a model which would allow the problem to be related to a possible solution.

5. To identify methodologies appropriate for investigating the problem and for subsequent use in assessment of its reduction.
Given the potential diversity of the workplace situation, if assessment was confined merely to how well novices performed, valuable aspects of the problem might not have been captured. Thus, to try to obtain as complete a picture as possible, the way in which novices approached the task, i.e. their behaviour(s) was also assessed.

It was necessary to assess whether novice performance in the workplace could be improved. In other words, was there a gap between the 'actual' performance of novices and 'target' performance, and might this therefore, be reduced. To address this question, the performances and behaviours of experts in the workplace were compared to those of novices. In defining the experts it was assumed that people with substantial practical experience would have achieved a more desirable level of performance than subjects without such experience. It was possible, however, that experts would have developed 'bad habits' and could demonstrate inferior performance, therefore the validity of the assumption made was partly assessed by the study.

3.2.3 The training programme

Despite the existence of numerous training programmes, their effectiveness in reducing back pain is limited. To explore the reason for this, a first question to ask is: Is the training offered adequate? This mandates consideration of the nature of the training. A training programme can be loosely divided into lecture instruction and practical instruction. The former conveys theoretical information, for example, knowledge concerning the anatomy of the spine. Practical instruction can be defined as providing the knowledge required to make a safe and effective movement. For example, it may include knowledge concerning
how to transfer a patient safely and effectively from a wheelchair to a bed. If the training programme is inadequate, there may be a deficiency in the lecture knowledge, the practical knowledge, or in the relationship between these knowledge types.

Presumably, when both lecture knowledge and practical knowledge are adequately acquired and remembered, they will support adequate classroom behaviours and, in turn, adequate workplace behaviours. Conversely, when neither lecture knowledge, nor practical knowledge are adequate, little support will be provided for either classroom or workplace behaviours. Between these extremes intermediate scenarios may exist in which either the lecture knowledge and/or the practical knowledge are inadequate, leading to inadequate classroom and/or workplace performance. For example, the lecture knowledge may be adequate but the practical knowledge may not support workplace lifting. There are several possible reasons for this. For example, the practical knowledge may be acquired but forgotten, or it may contain omissions so that it supports the lifting and handling of people, but not of objects.

The training programme selected to investigate the research problem was that used to train physiotherapy students at King's College, University of London. It was chosen on the basis of being reasonably representative of expert opinion (Troup and Edwards, 1985) and of current training practice in British undergraduate physiotherapy programmes (Ellis, 1993).

Thus, the programme included basic anatomy and elementary mechanical principles. It was
based mainly on the teaching of fundamental principles applicable to all handling tasks, and reflected in the, 'straight back, bent knees' profile previously described (see section 2.3). The instructional methods included lectures, video, handouts, demonstrations, and supervised practice. The programme consisted of seven hours of training across an academic year. One hour of theoretical instruction was followed by three, one hour sessions involving demonstration and practice of patient-handling techniques. The programme included use of a demonstration video. The college based teaching was followed by a hospital based workplace assignment of approximately three hours. This assignment required students to observe clinicians handling patients and to complete a written exercise based on their observational experience (see Appendix 1 for full training programme).

The basis of most forms of training is to give students an opportunity to acquire and practice knowledge in one situation which can then be used in another situation. Only if students' performances in the workplace were markedly worse than those in the classroom would a problem exist. In taught students, the aim is for their performance of patient-handling tasks to reflect adherence to commonly applied rules. These rules reflect ways of reducing the stresses placed on the students' spines and hence, reduce their risk of injury. Clearly, implementation of the taught rules may be influenced by environmental or task constraints.

Target performance for a particular patient-handling task is defined as that in which the rules are adhered to to the maximal extent possible, within the physical constraints of the
situation. Target performance can be contrasted with 'ideal' performance which, theoretically, would entail complete adherence to the rules, but which in practice may not be achievable. This definition of 'target' performance permits legitimate comparison of patient-handling performances in different circumstances. The closer 'actual', i.e. workplace, performance is to 'target' performance, the smaller the problem and conversely.

It is unlikely that students would achieve 'target' performance, and anecdotal evidence suggests that even experts are unlikely to always meet the criterion. However, the distinction of 'actual' versus 'target' performance and use of the notion of the 'target' standard, facilitates assessment of the level of deficiency in a student's performance. Consequently, reduction in that deficiency can be aimed for. The overall aim of training programmes is to support behaviours which reduce the likelihood of patient-handling-related back pain or injury. Within this remit, aiming for a reduced deficiency, even if in absolute terms performance is not 'good', seems acceptable, as subjects may be placed into a situation with reduced potential for injury.

3.2.4 Requirements of data collection methods

Training programmes aim to produce in the novice, a set of desired behaviours, the quality of which is reflected in performance. Some individual physical behaviours, for example, 'get as close to the load as possible', when assessed relative to a desired criterion may be scored. The scores obtained from assessment of several behaviours may be aggregated to give an overall measure of performance. Other behaviours are less amenable to scoring,
(for example, instructing a patient), thus indicating a requirement for the use of one or more reasonably flexible, open-ended data collection method(s), likely to capture as many behaviours as possible.

Clearly, only a subset of all the physical behaviours occurring could feasibly be considered with respect to performance. Although some controversy exists concerning the 'correct lifting technique' (Parnianpour et al 1987, Venning, 1988; Garg, 1990), as there is a reasonable degree of agreement on the basic principles which should be taught, consideration of a subset was deemed to be adequate for the purposes of an exploratory study. The physical behaviours assessed were chosen for two reasons. First, because of their importance in terms of established, desired patient-handling practice (Troup and Edwards, 1985). Second, on the basis of being principles which are frequently required to be applied when carrying out patient-handling manoeuvres. The following behaviours formed the basis of the performance assessment:

1. Maintaining the load close to the body
2. Keeping the back straight
3. Avoiding jerkiness - handling smoothly
4. Avoiding unnecessary twisting
5. Ensuring an adequate grip

3.2.4.1 The selected data collection and analysis methods

Although direct observational methods have previously been used in patient-handling studies (Wachs and Parker, 1987; St Vincent and Tellier, 1989; Jackson and Liles, 1994),
the difficulty of controlling for any observer bias, and the absence of the facility to review
the data led to sole use of such methods being rejected in favour of the combined use of
observation and videorecordings for data collection. Similarly, it was decided that
interviews would facilitate the collection of much richer data than self-administered
questionnaires. This richness was desirable in view of the exploratory purpose of the
study. Semi-structured interviews were chosen because, given the difficulties associated
with verbalising knowledge concerning how to do something (procedural knowledge), it
was felt that subjects would find it easier to respond accurately if they were prompted.

3.2.4.2 Data collection - developing a questionnaire format for the interviews
A questionnaire was developed to facilitate exploration of the relative adequacy of the
lecture and practical parts of the training programme, and to provide a basis for
understanding any differences in classroom and workplace performance. The content and
wording of the questions was tested and improved in informal trials with three people
trained in patient-handling. This resulted in the addition of some questions, for example,
Question 12 concerned with assessment of an individual's ability to assess their own level
of risk. Subjects were also asked whether they thought that they, or other people,
consistently complied with training in patient-handling and if not, what they perceived to
be the reasons for non-compliance.

The final questionnaire upon which the semi-structured interview was based comprised
a series of sixteen questions. Attached to each of the sixteen questions were descriptive
five-point scales. The decision to use a five-point scale was an arbitrary one. The full
questionnaire appears in Appendix 1.

3.2.4.3 Data analysis - performance checklist

Analytic options range from qualitative assessments of performance to quantitative analyses of movement parameters. Quantitative analysis was rejected because, in a complex environment where the emphasis was on assessment of performance relative to what the physical environment allowed, it was impractical to collect data from two unobscured views simultaneously. Furthermore, substantial error was likely to be incurred due to subjects' clothing. Had adequate camera positioning been possible, the influence of two carefully positioned cameras on subjects' performances is likely to have been considerable, leading to loss of ecological validity.

Thus, for analytic purposes, a performance checklist was developed. It was based on that previously used by Chaffin, Gallay, Wooley and Kuciemba (1986) in a study of warehousemen. However, it incorporated descriptive four-point scales not dissimilar to the three-point scales used by St Vincent and Tellier (1989) in their study of patient-handling. The decision to use a four-point scale rather than a three or five-point scale was an arbitrary one aimed at increasing the sensitivity of the checklist without sacrificing reliability.

In health workplaces, optimum body postures often cannot be assumed because of constraints such as space limitations and equipment interference, e.g. unadjustable beds. Furthermore, a patient-handling technique may have hidden disadvantages. For example,
the application of a particular technique may be advantageous from a postural point of view, but may impede the smoothness with which handling occurs, rendering compromise necessary (St Vincent, Lortie, and Tellier, 1987). Similar observations have been made in other manual handling contexts leading to the conclusion that the biomechanically based recommendations for 'correct lifting' are rarely practically applicable (Kuorinka, Lortie, and Gautreau, 1994). For these reasons and because the aim was to identify compliance with taught procedures, the criteria in the checklist were all defined in a relative sense using the qualifier 'as possible'. Thus criterion 1 became: 'Did the subject get as close to the load as possible?'. The checklist assessed the five manual handling behaviours identified previously:

1. Did the subject get as close to the load as possible?
2. Did the subject keep the back as straight as possible?
3. Did the subject lift/handle as smoothly as possible?
4. Did the subject avoid unnecessary twisting as far as possible?
5. Did the subject ensure adequate grip as far as possible?

When the checklist was used to assess a subject's performance each criterion was scored 0, 1, 2, or 3. An overall performance score between 0 and a maximum of 15 could be achieved. The full checklist appears in Appendix 1.

3.2.4.4 Checklist reliability and validity

Inter and intra-rater reliability were assessed as part of the study (Appendix 2). The checklist was assumed to have face validity on the basis that its criteria are consistent with biomechanical theory concerning ways of reducing stress on the spine. This theory
predicts some relationship between the criteria, for example if the subject is as close as possible to the load, then the trunk should be able to be held reasonably straight. No attempt was made to formally validate the checklist, for example, by perhaps using the checklist alongside quantitative assessments of subjects' performances under ideal conditions. Such quantitative assessments would be difficult to make and, furthermore, the comparison of judgments made by two raters provided a crude indication of its validity. This was deemed adequate for the purposes of the present work.

3.3 STUDY 1

3.3.1 Introduction

This study is not strictly experimental in the conventional laboratory sense since it lacks the requisite control conditions. However, given its status as a study to explore the existence and nature of the problem in as naturalistic a manner as possible, the use of a novice group of subjects in the classroom, and workplace settings, and of an expert group in the workplace setting, provides some level of control over the variable of lifters' knowledge. A between groups comparison of novices' and experts' workplace performances was possible, and a within groups comparison of novices' classroom and workplace performances.

3.3.2 Hypotheses

Hypothetically, it seemed likely that there would be a significant difference between novices' performance scores in the classroom and their performance scores in the
workplace. On commonsense grounds, it was presumed that novices would perform better in the classroom, the implicit assumption being that they would perform better on 'more familiar' tasks, which were obviously similar to those learnt in the training programme. However, it was possible that novices would perform better or at least similarly in the workplace if, for example, they were more motivated in the latter situation.

It was also postulated that experts' performances in the workplace would be significantly better than those of novices, on the premise that practical experience is likely to lead to more skilful performance. This assumption was the basis of using the experts as a group against which to compare the novices. The use of experts for comparison had two further purposes. First, it facilitated more detailed consideration of the sensitivity of the assessment procedures. Secondly, it provided a means of obtaining insight into areas of deficit which might be amenable to improvement by redesign of the training programme.

3.3.3 Subjects

3.3.3.1 Novices

Eleven undergraduate physiotherapy students (ages 18-25; male=2, female=9) who were undertaking a four-year degree course programme, participated in the study in years one and three of their programme. Volunteer subjects were recruited by personal invitation. The purpose of the study was explained to the subjects. Written consent was obtained from the patients who were handled.
Subjects were asked whether they had any history of low back pain, as such subjects might reasonably be expected to be more responsive or, at least, to respond differently to training in patient-handling. All subjects had undergone routine health clearance prior to the start of their undergraduate programme. No subject had received any previous formal exposure to patient-handling training prior to undertaking the training programme.

3.3.3.2 Experts

Eleven experts were recruited, by personal approach, from three London hospitals:

Experts were defined as:

a) physiotherapists with more than 3 years, full time, post-qualification clinical experience
b) physiotherapists who had held responsibility for teaching patient-handling to other health care workers

All the experts were currently working as senior physiotherapists in the field of neurological rehabilitation where they were required to perform substantial amounts of patient-handling daily.

3.3.4 Procedure

3.3.4.1 Specific Training Programme (STP)

The specific training programme was that previously described. The full programme

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1 St Thomas' Hospital, Lambeth; St George's Hospital, Tooting; Lewisham General Hospital, Lewisham.
appears in Appendix 1.

### 3.3.4.2 Classroom assessment of novices

Novices were videorecorded whilst performing a patient-handling task on a student 'model' in the classroom setting following completion of the training programme. The assessment required each subject to answer questions concerning patient-handling and to demonstrate at least one handling manoeuvre on a 'model' patient with a particular 'medical condition'. Subjects wore standard clothing, i.e. physiotherapy uniform. The classroom environment permitted application of the principles of patient-handling as taught, for example, there were no space constraints and the bed height was readily adjustable.

Subjects were assessed by one of two assessors. Both assessors were experienced physiotherapy lecturers, and each had more than ten years experience of assessing students. Subjects were questioned verbally to test their lecture knowledge and were scored on this using a 1-5 scale. A score of three represented an acceptable level of knowledge required to pass the theoretical element of the assessment, and scores of 5 and 1 represented levels of knowledge well above, and well below that expected respectively. The videorecordings were subsequently assessed by two independent raters using the performance checklist. To pass the classroom assessment subjects had to score at least 60% on the practical part of the assessment, i.e. a checklist score of 9 or more.
3.3.4.3 Workplace assessment of novices and experts

Subjects were videoed again two years later, in one of five health workplaces, while performing two patient-handling tasks. The tasks were performed during subjects' normal working routines, on a working day chosen at random. A two-year gap between the classroom and workplace assessments was chosen as students only visit the clinical workplace for eight weeks during the summer of the second and third years of the undergraduate programme (see Appendix 1). Hence after two years they can still, arbitrarily, be classified as novices. Although the second year of clinical experience allowed students to apply their patient-handling skills and therefore perhaps to improve them, this experience was mainly in areas where there were either few handling requirements, or the handling occurred in situations where reasonably unobtrusive observation would have been difficult.

The workplaces used, were the neurological rehabilitation areas of six clinical centres in London\(^2\). Permission was obtained from the relevant Therapy Manager of each centre. Subjects wore standard clothing, i.e. physiotherapy uniform. The observer followed subjects as unobtrusively as possible. The first two handling tasks in which patient consent, and a reasonably unobstructed, roughly sagittal plane view could be obtained were videoed. Two tasks were selected for two reasons. First, they provided an informal, face-value check on the representativeness relative to the subject's usual performance of the task to be analysed. Second, they allowed the subject to become familiar with being

\(^2\) St George's Hospital, Tooting; St Thomas' Hospital, Lambeth; Lewisham General Hospital; The Wolfson Rehabilitation Centre; Oldridge Road Children's Centre, and the Royal Home and Hospital for Incurables, Streatham.

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videoed, and hopefully minimise any change in behaviour as a result of being videoed. The second task was used for data analysis.

Two difficulties were associated with the use of videorecordings. First, in view of the confidential nature of the therapist-patient relationship, audiorecordings were not made. Secondly, as the video was positioned, as far as possible, at right angles to the patient being handled, there was a danger that some behaviours associated with the task might not be captured. For example reading a patient’s notes often takes place at a central reception desk rather than in the workspace in which the patient is to be handled. To try to overcome these difficulties and ensure as rich a capture of data as possible, the observer chronologically noted the behaviours carried out by a subject in association with the task performed.

To try to produce an accurate assessment of subjects’ behaviours in the workplace it was desirable to record subjects’ ‘usual’ behaviours, as contrasted with, specimen ‘best’ behaviours which may have led to underestimation of the problem. To try to ensure this subjects were told that the purpose of the videorecording was to enable assessment of the quality of teaching they had received, rather than to consider their performance as individuals.

Following the second handling task, subjects underwent semi-structured interviews, in which they were questioned about their behaviours. They were also asked if they had experienced low back pain associated with the activity of handling patients. All interviews
were conducted by the same interviewer. Subjects' spontaneous comments were recorded. Assessment of subjects' behaviours was made from the videos and from the observer's notes. At the end of the session subjects were debriefed.

3.3.5 Data Analysis

The principal data obtained were:

1. Independent raters' judgments using performance checklists of:
   i) novices' classroom performances
   ii) novices' workplace performances
   iii) experts' workplace performances

2. Questionnaire responses concerning factors influencing novices' behaviours

3. Videorecordings and observer's notes providing a low level description of the overt behaviours as follows:
   i) novices' workplace behaviours
   ii) experts' workplace behaviours

The method of analysis for each of these will be presented in turn.

3.3.5.1 Performance checklist - Raters' judgments

The videorecordings were viewed by two independent raters, one of whom had participated in making the classroom assessments. Both raters were physiotherapy
lecturers, and each had more than fifteen years experience of teaching patient-handling and of making observational-based assessments of students. The raters were exposed to videos of 'good' and 'poor' performance which they rated until their judgements appeared consistent. During the training procedure one rater was very erratic and would have required very much more extensive training, so a replacement rater was recruited. The raters were regularly asked to justify the ratings they awarded. For example, they were asked questions such as: 'Why have you awarded a 2 and not a 3 for closeness?' and 'What makes this subject a 1 for grip and not a 0 or 2?'. The experimenter also regularly reminded them of the 'as possible' qualifier added to each criterion.

The raters judged each subject's performance, in the classroom and the workplace, using the performance checklist. Each video could be viewed up to five times by each rater. The raters were also asked to rate the level of risk they perceived the subjects to be at on a 1-5 scale. A score of 5 represented a high risk of injury, pain or discomfort, whereas a score of 0 represented no real risk. These data were compared with subjects' perceptions, assessed by way of the interview. Each rater judged each videorecording on two separate occasions which were at least ten days apart to minimise any recall. To reduce any cross-influence from the ratings awarded to each criteria and to each subject, the raters called out the rating, which was then noted by the experimenter. To try to preserve the rater's vigilance, every 15-20 minutes or six videos, whichever was the shortest, the rater was invited to rest for about five minutes. After each one hour session the rater rested for about 20 minutes.
3.3.5.2 Interview analysis

The number of responses to each question in each scoring category was identified. Questions 12 and 14 of the semi-structured interview schedule concerned with subjects' perceptions of risk and of environmental constraints respectively, were designed to assess the accuracy of subjects' perceptions. Hence, subjects' responses to these questions were compared with the judgments of an independent rater. Spontaneous comments made during the interviews were noted.

3.3.5.3 Behavioural analysis

Using the videorecordings, experimenter's notes and an informal description of domain objects and subjects' actions, significant behaviours were counted and classified. This enabled analysis of the frequency of the behaviours observed. The behaviours were classified on an arbitrary temporal basis into one of three stages: the preparatory stage (defined as activities prior to actual change of a patient's position), the lifting stage (defined as activities concerned with changing a patient's position), and the post-lifting stage (defined as activities subsequent to a patient being moved).

3.4 Results

With respect to the performance data, given that the assumptions of normality and homogeneity of variance appeared to be satisfied, and on the assumption that the scale underlying the judgments of performance was linear, parametric statistical analyses were used, in accordance with the recommendations of Huck and Cormier (1996). P < 0.05 was
taken as the criterion for statistical significance. All tests were two-tailed except where stated.

3.4.1 Nature of Patient-handling tasks assessed

Data were analysed for a total of 33 tasks. This represented data analysis of one task performed by each expert and novice in the workplace and one task performed by each novice in the classroom. The tasks were classified as follows:

Class 1: Moving or handling a patient on a bed

Class 2: Transfers: moving a patient from bed to chair or chair to bed

Class 3: Assisted standing/walking (including picking up a child)

The distribution of workplace tasks analysed in each class was as shown in Table 3.0. As subjects' performance of tasks in each of the categories was constrained in some way, the difficulty of tasks in each of the different classes was not expected to differ substantially. Therefore, the different frequencies in the cells should not have influenced the outcome.

Table 3.0

<table>
<thead>
<tr>
<th>Task class</th>
<th>Novices (CR)</th>
<th>Novices (WP)</th>
<th>Experts (WP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 11</td>
<td>n = 11</td>
<td>n = 11</td>
</tr>
<tr>
<td>Class 1</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Class 2</td>
<td>4</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Class 3</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

CR = classroom, WP = workplace
Five of the novices had experienced low back pain which they associated with the activity of patient-handling.

### 3.4.2 Reliability of checklist

To estimate the reliability of the checklist, Pearson's product-moment correlations were used to assess the strength of the association between the overall performance scores given by: rater 1 on the first and second rating occasions, rater 2 on the first and second rating occasions, and rater 1 on the first rating occasion compared to rater 2 on the first rating occasion. However, because Pearson's correlation coefficient has limited usefulness in assessing reliability, in that it may take the value of one even when one observer consistently rates twice as highly as the other, the intra-class correlation was also calculated. This depends, in part, on the product-moment correlation but is also dependent on the differences between the means and standard deviations of the two sets of scores. All of the scores were significantly associated (p < 0.01) as reflected in the correlation coefficients in Appendix 2 which range from 0.855 to 0.926.

The main results presented in the remainder of this chapter are based on rater 1's scores. However, to demonstrate that the use of rater 1's judgements does not substantially alter the main findings, analysis based on rater 2's data is also presented in Appendix 2.

### 3.4.3 Classroom performance scores of novices

As shown in Table 3.1, the mean performance score achieved by the novices in the classroom was 11.91 (sd = 1.37). The range of scores was 9-14. To pass the practical
aspect of the classroom assessment subjects needed to score 9 out of a possible maximum of 15. Subjects' lecture knowledge was also found in all cases to be of an acceptable standard (mean = 3.45, sd = 0.52). The full set of classroom scores appears in Appendix 2.

3.4.4 Workplace performance scores of novices

Table 3.1 shows that the mean performance score achieved by the novice subjects in the workplace was 8 (sd = 3.16). The range of scores was 4-13. The full set of workplace scores appears in Appendix 2.

To test the hypothesis that there would be a significant difference between novices' classroom and workplace scores a Student's t-test was used. This revealed a highly significant difference (T=4.87, p=0.0007, df=10). To test the hypothesis that novices who performed better in the classroom would also perform better in the real world, the classroom and workplace scores were correlated using a one-tailed Pearson's product-moment correlation coefficient, resulting in a significant r value of 0.552 (df = 9, p < 0.05).

3.4.5 Workplace performance scores of experts

As shown in Table 3.1, the mean performance score achieved by the experts in the workplace was 12.91 (sd = 1.87). The range of scores was 9-15. The full set of experts' workplace scores appears in Appendix 2. A two sample t-test revealed a significant difference between novices' and experts' workplace scores (T=4.43, p=0.0004, df=20).
Table 3.1

Mean (SD) performance scores of novices in classroom (CR) and workplace (WP) and of experts in workplace (WP)

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novices CR</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>11.91</td>
</tr>
<tr>
<td>SD</td>
<td>1.37</td>
</tr>
<tr>
<td>Range</td>
<td>9-14</td>
</tr>
<tr>
<td>Novices WP</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>8</td>
</tr>
<tr>
<td>SD</td>
<td>3.16</td>
</tr>
<tr>
<td>Range</td>
<td>4-13</td>
</tr>
<tr>
<td>Experts WP</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>12.91</td>
</tr>
<tr>
<td>SD</td>
<td>1.87</td>
</tr>
<tr>
<td>Range</td>
<td>9-15</td>
</tr>
</tbody>
</table>

3.4.6 Novices' and experts' workplace behaviours

The frequency of each of the identified behaviours for novices and experts is shown in Appendix 2. The small expected values in each cell precludes statistical analysis. Table 3.2 shows those behaviours which appeared to distinguish novices and experts.

Many behaviours were common to novices and experts. Subjects in both groups:

- communicated with the patient
- assessed the clinical situation
- prepared the patient
- removed arms and/or footplates from wheelchair
- positioned patient's hands and/or arms and/or feet
- positioned themselves and moved closer to the patient
- rearranged the patient's position following lifting

In the preparatory phase of lifting, as Table 3.2 shows, experts seemed more likely than novices to:

- decompose the task into subunits
- clear the workspace of relevant objects, i.e. those likely to interfere with a subject's performance of a task
- adjust the bed
- arrange pillows on the bed
- position the patient's feet
- check that the patient was free of any encumbrances to movement.

During the lifting phase, experts seemed more likely to:

- move the patient to the edge of the bed or chair
- continue instructing the patient during the manoeuvre
- respond to unexpected events.

Conversely, novices appeared:

- less likely to break the task down into subunits
- less likely to clear the workspace appropriately.

For example, novices tended to focus on moving objects, the position of which, was irrelevant to the execution of a lift. Novices also appeared to be less able to respond to unexpected events.

There appeared to be fewer differences in the behaviours performed by novices and experts in the actual lifting phase than in the preparatory phase, although as the performance scores showed, the quality of execution of the behaviours differed markedly.
## Table 3.2

Frequency of behaviours with marked differences between novices and experts

<table>
<thead>
<tr>
<th>Behaviour Description</th>
<th>Novices</th>
<th></th>
<th></th>
<th>Experts</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRESENCE OF BEHAVIOURS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B4 Preparatory behaviours</td>
<td>Yes</td>
<td>1</td>
<td>7</td>
<td>Yes</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Explain task to patient by breaking whole task into subunits</td>
<td>No</td>
<td>7</td>
<td>3</td>
<td>No</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>B5 Clear workspace - move mainly relevant objects cluttering space, e.g. locker, stools</td>
<td>Yes</td>
<td>2</td>
<td>6</td>
<td>Yes</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>6</td>
<td>3</td>
<td>No</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>B8 Position or adjust bed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B10 Apply brakes to wheelchair and/or get assistant to stabilise</td>
<td>Yes</td>
<td>5</td>
<td>3</td>
<td>Yes</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3</td>
<td>3</td>
<td>No</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B11 Arrange pillows on bed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B13 Position patient's feet or instruct patient where to place feet</td>
<td>Yes</td>
<td>5</td>
<td>3</td>
<td>Yes</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3</td>
<td>3</td>
<td>No</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B14 Check/ensure freedom of encumbrances to patient's movement, e.g. tight clothing, orthoses, catheters</td>
<td>Yes</td>
<td>3</td>
<td>6</td>
<td>Yes</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>6</td>
<td>2</td>
<td>No</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>B16 Lifting behaviours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Move patient to edge of bed/chair</td>
<td>Yes</td>
<td>4</td>
<td>5</td>
<td>Yes</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>5</td>
<td>2</td>
<td>No</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B18 Instruct patient during manoeuvre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B21 Enquire about/check patient's state</td>
<td>Yes</td>
<td>4</td>
<td>5</td>
<td>Yes</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>5</td>
<td>2</td>
<td>No</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B22 Respond to unpredictable event which impedes patient during movement, e.g. difficulty with splint, patient becomes unsteady, nervous</td>
<td>Yes</td>
<td>2</td>
<td>5</td>
<td>Yes</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>5</td>
<td>4</td>
<td>No</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Key:  
- **n/a** = not applicable to task;  
- **u/c** = unclear whether behaviour occurred
3.4.7 Reasons for differences in novice performance in the classroom compared to the workplace

In relation to the questionnaire data, the novices failed to identify any problems with the lecture knowledge components of the programme (Questions 1-4). The principal problems identified related to the practical components of the programme. Although the clarity of demonstration material and the quality of feedback were deemed adequate, (Questions 5, and 7, respectively), nine novices identified insufficient practical time (Question 6), and eight reported difficulty in remembering the practical parts (Question 8). Just under half (5) of the subjects reported having a poor understanding of the practical parts (Question 9). Five subjects reported that the task required a large mental effort and four that it required a large physical effort (Questions 10 and 11 respectively). Novices' perceptions of their level of risk (Question 12) and of the constraints imposed by the environment (Question 14) were variable. As the data were ordinal and not normally distributed they were compared to the assessments made by rater 1 using one-tailed Spearman's correlation coefficients which showed subjects' perceptions to be reasonably accurate (Questions 12, rho = 0.828, p < 0.01, Question 14, rho = 0.804, p < 0.01).

Most subjects (9) claimed that their ability to handle had improved since their classroom assessment (Question 15) and almost all (10) claimed to have been motivated when undertaking the classroom assessment of their performance (Question 16). The questionnaire responses are summarised in Table 3.3. A full set of responses, along with samples of subjects comments appears in Appendix 2.
Table 3.3

Summary of questionnaire responses

<table>
<thead>
<tr>
<th>Question (number and content)</th>
<th>Desired response</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Level of lecture material</td>
<td>3</td>
<td>3</td>
<td>2-3</td>
</tr>
<tr>
<td>2. Emphasis on main lecture points</td>
<td>5</td>
<td>4</td>
<td>3-5</td>
</tr>
<tr>
<td>3. Use of examples in lecture</td>
<td>5</td>
<td>4</td>
<td>3-5</td>
</tr>
<tr>
<td>4. Easy of remembering lecture material in workplace</td>
<td>5</td>
<td>4</td>
<td>3-4</td>
</tr>
<tr>
<td>5. Clarity of demonstrations</td>
<td>5</td>
<td>4</td>
<td>3-4</td>
</tr>
<tr>
<td>6. Amount of practice time</td>
<td>3</td>
<td>2</td>
<td>1-4</td>
</tr>
<tr>
<td>7. Quality of feedback</td>
<td>5</td>
<td>4</td>
<td>1-4</td>
</tr>
<tr>
<td>8. Ease of remembering practical material</td>
<td>5</td>
<td>2</td>
<td>2-4</td>
</tr>
<tr>
<td>9. Support practical material offered to understanding</td>
<td>5</td>
<td>3</td>
<td>2-5</td>
</tr>
<tr>
<td>10. Mental effort</td>
<td>5</td>
<td>3</td>
<td>1-4</td>
</tr>
<tr>
<td>11. Physical effort</td>
<td>5</td>
<td>3</td>
<td>2-3</td>
</tr>
<tr>
<td>12. Level of risk of injury</td>
<td>1</td>
<td>4</td>
<td>2-5</td>
</tr>
<tr>
<td>13. Application of taught procedures</td>
<td>5</td>
<td>4</td>
<td>2-4</td>
</tr>
<tr>
<td>14. Effect of physical environment on handling</td>
<td>5</td>
<td>3</td>
<td>2-5</td>
</tr>
<tr>
<td>15. Change in handling ability since taught</td>
<td>5</td>
<td>4</td>
<td>3-5</td>
</tr>
<tr>
<td>16. Motivation during classroom assessment</td>
<td>5</td>
<td>4</td>
<td>3-5</td>
</tr>
</tbody>
</table>
Chapter 3: Study 1

3.5 Discussion

This preliminary field study aimed to expose the existence of a problem concerning training in patient-handling by examining the performance and behaviour of novices and experts. Overall, the results indicate marked, statistically significant differences between novices' performances in the classroom compared to the workplace, and between novices' performances in the workplace and those of experts. Marked differences were also found between the behaviours of novices and experts. Possible reasons for the differences were identified and are discussed.

3.5.1 Novices' classroom and workplace performance scores

The significant difference (p < 0.001) between novices classroom performance scores and their scores in the workplace strongly supports the hypothesis. In general terms, adequate performance in the training situation followed by failure to perform adequately in the workplace situation suggests a problem with transfer of the knowledge acquired during training.

All the novices achieved reasonably high classroom performance scores indicating that, in this study, as in Videman et al's (1989) investigation, the taught techniques could in fact, be learnt. On the basis of an exploratory study, in which intensive training did not reduce subjects intraabdominal pressure, Stubbs et al (1983b), questioned whether it is possible for students to acquire patient-handling skills. Although it could be argued that the standard of classroom performance deemed acceptable was too low, the present findings seem to indicate that the acquisition of skills is possible. However, the means of
enhancing skill acquisition remains open to question.

The observed level of classroom performance is also at variance with that found by both Troup and Rauhala (1987) and Videman et al (1989). Troup and Rauhala assessed students' performances in the classroom using a single, three-point scale, the maximum score being three. Different points on the scale represented different notions of timing, technique selection, safety, and loading on the back. The mean score was 1.25, in other words, well below 50% of the maximum score. Videman et al (1989) used the same scale but with an increased number of increments. Although they found a significant difference between the performances of trained and untrained subjects, the mean score of the trained group again failed to reach 50% of the maximum.

In Videman et al's study (1989) the role, if any, of the assessment of a student's performance in relationship to a student's professional progress is unclear. In comparison, in the present study the classroom performance was a critical test in the assessment of a student determining a student's progress to other parts of the course. Hence, it is likely that the students were highly motivated and this may, in part, explain the higher levels of performance.

To some extent it could be argued that, in the present study, each of the criteria upon which the performance checklist is based are related. This may have led, in some cases, to a subject's performance being overassessed, effectively making it 'easy' to achieve a high score. For example, in some situations if a subject got close to the load (s)he was
forced, or at least encouraged, into a straighter back position. The mean classroom score (11.91) was just below 75% of the maximum score possible, whereas in comparison, subjects in Troup and Rauhala's (1987) study achieved a score which represented 40% of the maximum. Given the size of the comparative difference it seems unlikely that it can solely be attributed to one of possible overassessment. What seems more likely, is that the different results may reflect the use, by both Troup and Rauhala (1987) and Videman et al (1989), of a single all embracing measure of performance. Their scale also required assessment of several, variable dimensions of performance such as timing, safety, back loading (see section 2.4.1 of this thesis). In contrast, the assessment used in the present study, was derived from five relatively circumscribed subscores in which assessment of less easily defined aspects, for example, how well a lift was planned, was not attempted.

Obviously, when novices' classroom and workplace performances are compared, any concerns regarding any overassessment which the checklist may have imposed continue to apply. However, nothing suggests that there might be any systematic overassessment in one or other situation. Previous work has indicated fairly convincingly that people fail to apply taught principles in the workplace (Takala and Kukkonen, 1987; St Vincent and Tellier, 1989). Among other explanations, this failure has often been attributed to students' inadequate learning of the techniques when trained, or to environmental constraints (Videman et al, 1986). As few previous studies have considered performance in both the classroom and the workplace, the difference between novices' CR and WP performances found in the present study may indicate that such explanations only partially explain the problem.
There may not be a problem with transfer. An alternative view is that poorer performance in the workplace reflects the more severe physical constraints imposed by varied workplace situations. However, in Study 1 each of the performance criteria was defined using the term 'as possible'. This was a deliberate attempt to acknowledge that health workplaces are diverse and often unsatisfactory in ergonomic terms. This means that it is not always sensible to consider performance in isolation from the particular circumstances of the workplace evaluation (Kuorinka et al., 1994). Thus, for example, subjects were assessed according to whether they got as close to the load as possible. In this way it was hoped that the effect of any particular physical configuration of the workplace was accounted for within the assessment of performance. Furthermore, as subjects' responses to Question 14 revealed, they were evenly divided in terms of their perceptions of the influence of the environment on their performance.

The health workplace is a stressful, often time-pressured situation (Hawkins, 1987) and it could also be argued that this led to a decrement in workplace versus classroom performance. Several authors (Takala and Kukkonen, 1987; Garg, Owen, Beller and Banaag, 1991) have shown that one of the reasons people tend not to use mechanical lifting aids is that they are perceived to take too long to use. Extending this view, it seems possible that any optional action, for example, keeping the trunk straight when lifting, although known to be safer, if perceived by the lifter to be more time consuming, is unlikely to be complied with.

Linked to this is the view that the management control systems (Wood, 1987; Girling,
Birnbaum and Pheasant, 1988) or the safety culture of a workplace may influence the working practices (Luker, 1984). Although neither of these was specifically investigated in this study, only two of the novices spontaneously identified cultural norms as a factor which 'sometimes' affects their handling procedures. Cultural concerns might be expected to apply in a very broadly similar fashion to novices and experts alike, yet the experts' performances were acceptable. Furthermore, given that 'Physiotherapy is handling' (Williams, 1986) it seems plausible that in a population of student physiotherapists, the safety culture was more likely, if anything, to be higher than that in other occupational groups.

All the novices performed at least adequately in the classroom situation. Yet seven of them failed to do so in the workplace, and an eighth subject only just achieved an acceptable level of workplace performance. The classroom assessment differed from the workplace assessment in that it required interaction with the assessor and, second, students' attention was directed towards being assessed. It seems unlikely that any enhancing effect that these differences may have had on classroom performance would account for the substantial discrepancy between classroom and workplace scores. Furthermore, the association between novices' classroom and workplace scores was only just significant which would seem to underline the ineffectiveness of the training programme.

3.5.2 Experts' workplace scores

Experts' workplace performance scores, while still 'imperfect', were significantly better
than the scores of novices (p < 0.001), again strongly supporting the hypothesis. Three experts achieved the maximum score of 15, possibly indicating a substantial level of expertise, or perhaps reflecting a ceiling effect in the performance checklist. The variability in experts' scores (sd=1.87) was less than that in novices (sd=3.16) even though both groups were observed in several different workplaces. Even if this lower variability is, in part, attributable to any ceiling effect, it seems unlikely that the difference between novices and experts was due to the experts being in workplaces where it was, 'easier' to apply the principles supporting, 'good' patient-handling. One implication of the difference is that the deficiency in novice performance might be amenable to being reduced. To explore this further, it is necessary to consider the different ways in which novices and experts behave.

3.5.3 Novices' and experts' workplace behaviours

The recording and classification of behaviours was, to some extent, a matter of judgement and this must be borne in mind when considering the behavioural data. Nevertheless, marked differences between the behaviours adopted by novices and experts emerged as did many behaviours common to both groups.

In comparison to novices, experts' behaviours suggested two characteristics. First, the experts appeared to organise the task across a longer time horizon and secondly, they seemed to be more likely to respond to unexpected events. These will be examined in more detail in turn. Experts evidenced behaviours which seemed to indicate that they had thought through their intended plan of action. For example, they cleared the workspace more appropriately, confining themselves to moving relevant objects and to preparing and
clearing the destination area. Thus, for example, in the case of a catheterised patient transferring from bed to chair, experts were more likely to check that the brakes were on the chair, and to check that the catheter was free to move. They also tended to ensure that any chair was adequately positioned to facilitate transfer of the patient without having to interrupt the manoeuvre to reposition it. More detailed forward planning was also suggested by the fact that the experts were, in general, more likely than the novices to explain the task to the patient by breaking it down into subsections.

In contrast, novices in clearing the workspace, tended to pay attention to irrelevant objects whilst neglecting salient ones. For example, they tended to spend time moving peripheral pieces of furniture whilst failing to move objects in the path of the intended movement. Novices were also less likely to clear the destination area suggesting that they had not thought through the intended plan of action in the same way as experts. This was to some extent supported by the fact that, unlike the experts, the novices tended to explain the task to the patient in terms of the overall aim rather than by breaking the task down into subsections. Novices' apparent inability or reluctance to break the task down into subsections in advance suggests a bottom-up strategy of problem solving with little advance planning of the consequences of their current actions.

The differences between the strategies adopted by novices and experts parallel those observed in other domains such as physics and chess. For example Chi, Glaser and Rees (1983) found that although experts solved problems faster than novices, they spent more time than novices analysing and understanding the problem. Experts also tend to evidence
working forward to a solution whereas novices tend to work backwards (Larkin, McDermott, Simon and Simon, 1980). The findings of the present study provide a basis from which to begin to refute Ohlsson's (1983) concern that most problem solving research has concentrated on what he calls, 'technical' knowledge domains rather than the natural domains of everyday life.

The second main characteristic distinguishing novices and experts was their response to unexpected events. Novices seemed less able to respond to unexpected events. This resulted in them being frequently found in situations whereby, for example, the chair was too far from the bed, or the patient was too encumbered to move. In contrast, experts seemed less likely to be 'stranded' by a poorly positioned chair or tangled catheter and, if this did happen, they were more likely to be able to respond. This suggests two possibilities. Either the experts were more able to predict likely problems and hence prevent them, or else the experts' strategies for action were sufficiently flexible to allow them to respond to the unexpected.

In seeking an explanation for these behavioural differences relative to the training programme, a question raised is:

*What knowledge are novices lacking?*

It appears that novices may be deficient in the high level knowledge required to plan the sequencing of their movements, and to adjust this planning in response to the changing demands of the situation. In relation to the training programme, novices' responses suggested that the theoretical instruction was adequate. It seems that it is the practical
instruction which fails to support the use of the theoretical knowledge at a level that is high enough to support, in novices, a flexible set of behaviours. These deficits seem to leave novices with little option other than to perform the task as best they can, in other words, to rely on the low level knowledge that they have acquired.

To summarise, it appears that in contrast to experts, novices exhibited relatively low level, non-strategic, and inflexible behaviours, evidenced in a, 'get in there and do' approach to the task, which was reflected in a poor level of performance. Conversely, experts demonstrated more strategic and flexible behaviours reflected in higher levels of performance. The implication is for the training programme to be enhanced so that it provides novices with the missing high level knowledge, such that the gap between novices' and experts' behaviours, and hence performance is reduced. Examination of some of the reasons for subjects' behaviours in the workplace enabled more detailed consideration of these aspects.

3.5.4 Reasons for non-compliance

Subjects identified as poor those components of the training programme associated with the provision of practical knowledge. The suggestion is that it is these elements which need redesigning. No problems were identified regarding the lecture knowledge as indicated by the responses to questions 1-4. Subjects may have overestimated their acquisition of this knowledge, i.e. they thought that they remembered the theoretical elements of the programme, but in fact did not. However, as their responses to other questions such as Question 12 (concerning their assessment of risk) indicated a reasonable
level of self-awareness among the subjects, this seems unlikely. Furthermore, as the responses to Questions 1-4 so strongly supported the absence of problems with the lecture knowledge, it seems reasonable to conclude that these aspects of the programme are reasonably adequate.

The most clear-cut finding was that nine subjects found the amount of practice to be insufficient, suggesting that the practical knowledge may not be adequately acquired and so fails to support patient-handling in the workplace. We might have expected this to be detected by performance in the classroom assessment. That this was not so, presumably reflects either a classroom assessment that was too easy, or else the different requirements (mental and physical) of the workplace compared to the classroom. As far as the former explanation is concerned, Kroemer (1992) has highlighted the difficulty of identifying an appropriate measure to use following training and also the related issue of how well one must do on the measure to be considered trained.

Given the poor relationship between subjects' classroom and workplace performances, it seems more likely that it is the differing requirements of the workplace that explain this finding. For example, workplace performance requires the subject to have the knowledge to support the recognition of encumbrances to a patient's movement. Thus, it may be not that the training programme fails to support the acquisition of practical knowledge per se, but that it fails to support its acquisition at a sufficiently high level to support the behaviours required by a novel situation. It appears that what is required is a rational view of what subjects need to know to perform in the workplace. To develop such a view it
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seems necessary to integrate the cognitive and physical demands of the task.

Eight novices experienced difficulty in remembering the information conveyed in the practical parts of the programme. Their previously adequate performances in the classroom imply that the novices had acquired the practical knowledge but had since forgotten it. This is partly borne out by the fact that all subjects perceived the demonstrations to be clear (Question 5). Poor transfer has often been attributed to the fact that trainees may learn procedures supporting the performance of a task but may not be made aware of the range of tasks and associated circumstances in which the procedures should be used. As Gick and Holyoak (1987) point out, the trainee may not perceive the training and transfer situations as similar, even when they are. This view is, to some extent, moderated by the notion that strategies for performing tasks are highly situation specific (Hayes, 1985) and will inevitably vary when applied to new situations. However, in the light of subjects' comments, it appears that they did experience difficulty relating the workplace requirements to their classroom teaching. It seems that advancement of these ideas may be contingent on the development of models of transfer for different classes of tasks.

As the classroom scores indicated that the original learning was adequate, a further question raised is:

*How can retention be increased?*

In the initial training programme, subjects underwent three, one hour practice sessions at weekly intervals. It may be that in the acquisition of practical knowledge required to
support patient-handling tasks, an increased amount of practice time, an altered
distribution of time, or a different type of practice might be desirable. For example, in the
programme used here, subjects were given no control over how they used the practice
periods and all the practice was physical in nature. It may be that a longer or shorter
practice schedule, at monthly or daily intervals and including physical and mental
components would be optimal. In assessing optimisation however, it is necessary to
remember that subjects' perceptions of practice may not be the most reliable indicators to
practice concerns (Lee, 1988) that will facilitate transfer. What seems clear is that any
change to the practice component of the training programme must aim to support the
acquisition of higher level knowledge.

A relationship between the quality of feedback perceived by subjects and their ability to
lift/handle might have been expected. Yet this was not evidenced, with seven subjects
responding positively to Question 7. In accordance with Lee's (1988) suggestions, it is
possible that subjects would not necessarily recognise 'poor' feedback. Thus the relatively
high quality of feedback perceived could have led subjects to become overly reliant on it
and changed their knowledge representation, so that, in the workplace, the absence of
such feedback changed the task significantly, necessitating different practical knowledge.
However, as the responses to Question 7 were not strongly positively skewed, this seems
unlikely.

Five subjects had difficulty in acquiring a, 'good understanding' of how to lift/handle in the
non-classroom context. If 'understanding' is synonymous with knowledge, subjects'
responses may have indicated an awareness of a deficiency in their practical knowledge, such that it was unable to be adapted to support performance in different situations. It might have been thought that subjects found it difficult to distinguish their ability to remember what to do from their understanding of what was required. Subjects' comments, however, indicated that they could make a distinction. The acquisition in the classroom setting of an, 'understanding' which is not good enough to be applied in the workplace, may relate to a deficiency in either the lecture knowledge or the practical knowledge despite the deficient knowledge itself being adequately acquired. Deficiency of the lecture knowledge was not evidenced. Deficiency of the practical knowledge may be due to a lack of practically relevant examples, or to subjects' inability to use the examples given in the workplace. Subjects' comments supported the latter indicating that they found it difficult to extrapolate to the situations they were in from the examples given.

Initially, it was postulated that the failure of practical knowledge to support workplace lifting might be because in the classroom, practical knowledge was acquired under conditions of few competing cues, whereas in the workplace the attentional demands are markedly different. This possibility was investigated by questioning subjects regarding their perceptions of effort, following the assumption that effort perception indicates attentional demands. Clearly, patient-handling is a task with many overt elements so it was necessary to distinguish subjects' perceptions of the physical effort involved from their perceptions of the mental effort involved. An initial concern was that in tasks of this nature subjects might find the distinction difficult to make but their comments do not substantiate this.
Hence, 'poor' performers found trying to implement the taught lifting/handling procedures effortful in mental terms. Five subjects associated a high mental effort with their patient-handling activities, possibly suggesting that the perception of mental effort related to attentional considerations in this situation. Perhaps even more interestingly, only one subject perceived lifting in the real world to be, 'fairly small' in terms of mental effort. In a task such as lifting it was possible that effort concealed problems of fatigue or attention switching. Yet, subjects' comments consistently showed that the consensus view was that 'effortful' represented increased attentional demands and the need to switch attention rather than a fatigue response.

Equally unexpected were subjects' perceptions of physical effort. In view of the relatively large loads being moved it might have been expected that perceptions of physical effort would be high. However, over half of the subjects considered the task to be, 'neither a big nor small effort' suggesting that it may not have been the physical elements of the task that were most salient to the performances of these subjects.

3.5.5 Assessment of methodology

One of the purposes of this study was to identify methodologies suitable for use subsequently, particularly in relation to the assessment of performance. Thus, it was reassuring to find that there were strong significant, positive correlations between the scores allocated by rater 1 on separate occasions and between those allocated by rater 1 and rater 2. However, the overall performance scores reflected varying patterns of scores on the different criteria so it was perhaps unsurprising that in relation to individual
performance criteria the agreements between judgments made on separate occasions and between those made by the two raters were very variable. This problem has been highlighted previously (Wachs and Parker, 1987).

This study is based on videorecorded data which raises several methodological issues. The presence of a camera may have led to observational bias, such that the behaviours captured were specimen, 'best' behaviours, or at least behaviours different from those normally exhibited by the subjects. However, it was emphasised that an individual subject's performance per se was not of interest, and furthermore, subjects were unaware of exactly when the camera was recording. The debriefing sessions confirmed that subjects soon forgot that the camera was there. In the worst scenario, assuming that subjects' performances, when videoed, were better than usual, this would indicate that the results presented here underestimate the true extent of the problem.

3.6 Summary and Conclusions

This chapter has evidenced the research problem and provided information concerning its nature. It has demonstrated a problem concerning novices' use of taught patient-handling skills in the non-taught environment, and has identified weaknesses in the training programme. It has suggested that it is reasonable to attempt to reduce the problem by enhancing training so that novices' ability to consider their behaviours in advance is supported. However, the requirement is for a means of relating the specified problem to the potential solution. To satisfy this requirement consideration of existing views of
transfer and training is mandated.
Chapter 4

THE SOLUTION REQUIREMENTS - A FRAMEWORK FOR A MODEL OF COMPLEX BEHAVIOUR

4.1 Chapter overview

Chapters 1 and 2 began to specify a problem in the training of patient-handling generally and Chapter 3 reported a specific instance of a problem. There are two elements to the requirements of a solution: the foundational conceptual requirements of the solution and how the conceptual requirements are implemented. This chapter addresses both by considering how they are informed by previous work. Hence, the chapter begins by briefly considering models of the acquisition of knowledge and its application. The aim is to identify a model, which supports reasoning about possible solutions to the specific problem, and enables generalisation of the identified features of non-compliance and of the prescribed solution. The chapter then considers the implications to training of previous work in order to permit specification of the range of possible solutions.

4.2 Introduction

The study reported in Chapter 3 identified a specific difficulty with novices' performances of taught patient-handling skills in the workplace compared to their performances in the classroom. It was suggested that there is a requirement for a more effectively designed training programme - one which addresses more explicitly the required mental behaviours.
Chapter 4: The solution requirements

This chapter describes a framework for considering the general research problem. In this thesis, a framework is conceived as a general set of ideas which are drawn upon by theorists in a particular discipline (see Anderson, 1983). Frameworks should be regarded as useful or not, rather than correct or incorrect. The reason for this is that they contain high level assumptions that can only be tested and validated by the testing and validation of models derived from the framework.

A model is an instantiation of a case within a framework, which relates the theoretical underpinnings of the framework to a specific situation in more detail. In patient-handling training, a model of students' knowledge would enable predictions to be made (and hence tested) of the likely effects of changed training on performance. This section considers first the requirements of a model that the framework is required to support and second, candidate frameworks. It culminates by describing an ergonomic framework. The latter is suitable for the address of both the general and specific research problems, and provides a basis from which Chapter 5 can address consideration of a specific model.

4.2.1 Frameworks

The choice of framework determines the kinds of problems that can be addressed and the types of solutions which can be produced. In patient-handling research, the emphasis has been on frameworks that focus on the physical aspects of tasks. This has led to reliance on three principal approaches: biomechanical, physiological, and psychophysical (Ayoub, 1992). Alternative frameworks include psychological ones. These are exemplified by consideration of the human as an information processor (e.g. Broadbent, 1958; Atkinson
Chapter 4: The solution requirements

and Shiffrin, 1968; Norman, 1981; Card, Moran and Newell, 1983). An information-processing view suggests that basic human data are relevant to sensory, cognitive, and motor components of behaviour and to associated attentional and memory processes. Choosing a framework, by definition, constrains the approach to solving a problem. Hence, 'physical' frameworks tend to exclude an abstract perspective and conversely, 'abstract' frameworks tend to exclude a physical perspective. In comparison, an ergonomic framework can focus on the interaction between mental and physical aspects of behaviour. However, it may achieve this at the expense of low level details explaining either the physical or mental processes.

4.3 The requirements of a framework

Given that the research problem is one of training which is ineffective regarding its support of transfer of knowledge to the workplace, the model, and therefore the framework in which it is developed, must be able to:

- represent changes in knowledge over time, i.e. between the different stages of acquisition through to application

- represent knowledge in different situations and of different sorts of objects, i.e. classrooms; different clinical situations. Hence, there is a requirement for the relationship between task behaviour and the knowledge supporting it to be represented.
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- capture those features of training which, if modified, may affect the effectiveness of a training programme. Therefore, the type of training and the way it is conducted must be captured as must the types of knowledge being transmitted.

- capture those features of transfer which, if instantiated, may affect training and may contribute to the design of more effective training programmes. For example, different degrees and levels of transfer need to be encapsulated to enable high and low level, and complete and incomplete behaviours to be captured.

The intended application of the research is to the design of patient-handling training programmes such that the discrepancy between the performances of novices and experts is reduced. Therefore, the relationship between the relevant features of training and of transfer must be able to be described, so that the effects on transfer of changing training can be rationalised. The next section considers models of transfer to assess their ability to fulfil the requirements outlined above.

4.4 Psychological frameworks - Transfer

4.4.1 Definition of transfer

Transfer includes both 'transfer of learning' and 'transfer of training'. The Department of Employment's (DOE) Glossary of Training Terms (1971) defined transfer of training as
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that which:

'occurs whenever the existence of a previously established habit or skill has an influence upon the acquisition, performance or relearning of another habit or skill. 'Positive transfer' occurs when the existence of the previous habit or skill facilitates learning the new one; 'negative transfer' refers to the interference by a previously learned habit or skill on new learning'.

(DOE, p32)

Clearly, the DOE (1971) definition of transfer emphasises the effect it has on the learning of new skills and the performance in new situations. What constitutes a 'new' or 'old' skill or situation is debatable in that previous experience influences almost everything we learn and everything we do. Hence, when encountering a new environment, subjects may be specifically influenced by the knowledge and skills acquired previously in a similar environment. Transfer can be helpful or unhelpful, or previous learning may have no effect at all, i.e. there may be zero transfer. Training programmes aim to capitalise on previously acquired knowledge. They rely on the positive transfer of the knowledge acquired and behaviours learned in the training environment to new learning or performance in the real world.

Transfer is, therefore, important in different ways throughout training. For the sake of clarity, this thesis distinguishes between: transfer of learning, transfer of knowledge and transfer of training. Transfer of learning occurs when subjects use previous experience to learn a new task. Transfer of knowledge occurs when a trainee has to transfer skills developed during training to performance in the real world. Transfer of training is when
a previously established habit or skill influences the acquisition, performance or relearning of another habit or skill (see paragraph 1 of this section).

When subjects are specifically trained in one environment, for example, the classroom, and are then required to use what they have learned in a different environment, for example, the workplace, the possibility of subjects failing to demonstrate adequate performance in the second situation exists. This is potentially a failure in transfer of knowledge. This definition presumes that transfer is assessed on the basis of a 'first-shot' measure, obtained by assessment of a subject's performance immediately following training (Hammerton, 1967).

Transfer then, offers a likely source of a candidate model capable of representing knowledge changing over time and knowledge in different situations. It may in turn support the characterisation of novices' and experts' behaviours, relating their behaviours to performance, and the prescription of training. The remainder of this section briefly considers theoretical notions of transfer, to assess how they may inform the specific research problem.

4.4.2 Early models of transfer

Historically, theories of transfer have viewed it either in terms of 'faculty' psychology, i.e. the formal discipline theory, or in behaviouristic terms, i.e. the identical elements theory (Thorndike and Woodworth, 1901). The formal discipline theory was particularly popular with educationists such as Roark in the nineteenth century. Its premise is that faculties,
for example, memory, are exercised whenever a task involving that faculty is undertaken.

Thus, increasing a person's ability to perform one type of task would automatically increase their ability to perform other tasks. The assertion is that performance of two tasks depends on a common capacity which can be developed by practising either of the tasks.

In comparison, the identical elements theory was proposed by Thorndike and Woodworth (1901), following their demonstrations of a lack of positive transfer between learning to estimate the area of rectangles and estimating the size of other geometric figures. They found that positive transfer of performance only occurred when two tasks shared identical elements, and suggested that the degree of transfer was a function of the number of shared elements. Only in the latter half of this century have these theories of transfer been influenced by advances in cognitive psychology. Hence, attempts have been made to account for performance in terms of the basic processing of information (Broadbent, 1958), rather than to rely on classical learning theory.

4.4.3 Cognitive models of transfer

Miller, Galanter and Pribram (1960) conceive human skills as being governed by plans. Plans are a kind of flexible formula for producing behaviour appropriate to specific purposes in any given environment. Such behavioural plans comprise elementary plans which can be disassembled and reassembled in flexible ways to take account of different intentions or unexpected events. Learning a new task or skill involves assembling a new plan, which may have the same general structure as an existing plan, but may differ in its details. A new task may either involve many existing subskills, but in different
Theories rooted in information-processing posit that transfer is governed by the central concept of similarity between mental representations, i.e. similarity of plans (Annett and Sparrow, 1985). Learning entails assembling a new plan. If the new plan is similar to an existing plan, positive transfer is likely. However, transfer may be modified by intrusive errors if not all the plan's details are appropriately changed. Alternatively, if the plan is different, the trainee may not recognise the relevance of a previously learnt element. Both transfer problems have the same fundamental cause, that well-established plans tend to be recalled and put into action as wholes. Consequently, a now irrelevant subplan may be called up, or a relevant subplan may be invoked but may fail if it has not been appropriately incorporated into the overall plan. One problem with this theory concerns its practical application in that the intended scope of plans is unclear. For example, Are plans purely representational structures? If so, what processes are implied? Furthermore, what might be the form of the representation?

When detailed skills are not readily transferred from one situation to another, this is an indication that they are not under the control of the general plan which is currently in operation. For example, a subject may perform a handling manoeuvre entailing complex grips and foot positioning in the classroom but be unable to execute a similar manoeuvre in the workplace. This theory suggests that to encourage transfer, there is a need to identify the higher level skills (i.e. knowledge) which should be controlling behaviour in a given problem area. This knowledge needs to be delivered so it can be recruited to a
variety of contexts.

The implications of plan-based views of transfer are different from those of the previous two theories, as the mechanism of transfer is concerned with the strategies underlying behaviour in new situations. One practical implication is that training might be enhanced by using a large number of simulations. These would aid training to the extent that they afforded subjects the opportunity to uncover different strategies. A further implication is that when subjects are exposed to a variety of related material across different presentations, they can more easily integrate new material with that already in memory, into a common representation.

In relation to the findings of Study 1, the implication is that novices develop a plan that is too specific to the training situation to facilitate transfer to the non-taught situation. Similarly, Fotheringham (1984) in a study concerning the transfer of measurement skills, found that training in a vernier measurement skill using a micrometer showed poor transfer to use of a vernier height gauge. It seems that although the same principles underly measurement, the original training may be too tied to the specifics of a micrometer as opposed to teaching the general principles of measurement. A follow-up study compared the effectiveness of different transfer training modules provided after the initial training. Neither a module of extra practical exercises with micrometers, nor extra theoretical input improved transfer. However, experience with a wide range of measuring instruments and a module on the principle of vernier measurement did result in significant positive transfer of training. It appears that these additional modules had taught the
trainees something more than a routine procedure, that is, they had given them insight into a principle which could be applied across situations.

To identify in what way a plan might be too specific, the need is to specify more precisely how the knowledge acquired in learned skills can be represented, and what knowledge is generalised. Since Miller et al's (1960) seminal work, various authors have suggested forms for the representations. For example, in the context of the knowledge underlying skilled performance, Anderson (1987) developed a cognitive architecture called ACT* (1987) in which knowledge is represented as a series of productions expressed as 'IF....THEN' rules.

The concept of a plan introduced by Miller et al (1960) was also elaborated using the notion of schemas. Schemas are data structures for representing the generic concepts stored in memory, and are roughly equivalent to models of the outside world (Rumelhart and Norman, 1978). They have been exploited extensively in relationship to memory representations for movement (Schmidt, 1975), making them, at face value, likely candidates for characterising the knowledge acquired and transferred in patient-handling training. Other possible representations include data structures for representing stereotyped situations, i.e. frames. A frame is equivalent to a default plan which governs a particular situation (Minsky, 1975). Pollock (1988) used modified frames to model the knowledge which is transferred when people are trained on one word processor but are required to use another.
4.4.4 Summary

If transfer had only specific effects, i.e. if positive transfer only occurred to the extent that
the non-taught situation was similar to the training situation, then nonspecific training is
unlikely to be beneficial. Conversely, if transfer is supported by exercising mental abilities,
then virtually any training using that ability would be useful. The evidence so far suggests
that neither a strong general, nor a specific theory of transfer is sufficient. Neither
perspective offers an adequate explanation for the ineffective training identified in Study
1. The transfer literature focuses on description and explanation of the phenomenon of
transfer and emphasises the evaluation of performance but offers little as a prescriptive
tool. Hence, it is not readily operationalisable for the development of training
programmes. Furthermore, both physical and psychological frameworks have limitations
in the context of the research problem because of their reliance on a predominantly
physical or predominantly mental view of the world. What is required is a framework in
which the mental and physical aspects of behaviour are equally represented in separate,
but interacting specifications. One view which attempts to conceptualise mental and
physical behaviour and performance is an ergonomic framework proffered by Dowell and
Long (1989). This will be described next.

4.5 An Ergonomic framework

4.5.1 Characteristics of the selected ergonomic framework

Training can be viewed as work to be optimised. Hence, it seems logical to consider an
ergonomic framework as a likely means of supporting characterisation of the problem in
a way that allows it to be related to a solution. Dowell and Long (1989) developed their framework for reasoning about human-computer interactions. However, its level of specification is sufficiently high to allow many of its concepts to be useful in addressing the current research problem. The framework accommodates the different representations and processes implicated when appropriate discipline-based knowledge is applied to a specific problem. Only those components of the framework which aid characterisation of the research problem will be described.

Components of the framework:

Central to the framework is the concept of an interactive worksystem (IWS) which comprises human and machine behaviours together performing work. In the domain of patient-handling the elements of the learning worksystem are the physiotherapy student and the patient-handling training programme. In the workplace counterpart to the learning worksystem the elements of the worksystem are the physiotherapy student and any patient-handling aid(e), for example, a hoist or another person to assist.

Unlike many unidisciplinary frameworks, the ergonomic framework advanced by Dowell and Long (1989) introduces the notion of performance, not just of the person or of a machine within the worksystem, but of the interactive worksystem as a whole. The advantage of this conceptualisation, theoretically, at least, is that the support afforded to the modelling of real world behaviour and to design solutions, should have greater real world validity. For example, in the context of developing more effective patient-handling training programmes, the framework accommodates handlers with different physical and
Performance is defined as a function of the quality of work performed by the IWS and the costs incurred. In patient-handling, performance embraces the quality of handling and handler costs. Task quality represents how well the trainee manages to achieve the goal of a moved patient. Theoretically, task quality can be expressed in terms of a combination of factors. Examples are: patient comfort and welfare, patient safety, adequacy of a patient's new position, and the time taken to perform the task. Clearly, there may be tradeoffs among these criteria, with, for example, the most rapid completion of the task being incompatible with minimisation of a patient's level of discomfort whilst (s)he is moved. In practice, anecdotal evidence suggests that the organisational emphasis is often on the rapid completion of handling manoeuvres, in other words the desired level of task quality is one that is as fast as possible.

The main costs incurred by the worksystem are those physical and mental costs incurred by the handler and any aid(e). The primary purpose of the specific training programme was to support acquisition of the principles of 'good' handling and so to reduce the behavioural costs to the handler. Hence, it is assumed that those subjects in Study 1 who achieved higher scores on the performance checklist had lower costs than their lower scoring counterparts. In turn it is assumed that, by focusing on the, 'straight back, knees bent' principle of patient-handling, the physical costs incurred by the handler may be reduced, although it has previously been acknowledged that this assumption may not be valid in all situations (see section 2.2 of this thesis and Parnianpour et al, 1987; Garg,
Similarly, if mental costs are considered, when the trainee is working within an organisation where there is, for example, substantial time pressure, the level of mental stress is likely to be higher and the mental costs may increase.

Behaviour is defined as what the worksystem does. It comprises interacting physical and mental behaviours. Mental behaviours include the acquisition, storage and transformation of information. They involve the representation and processing of information concerning domain objects. Physical behaviours are supported by these mental behaviours, all mental behaviour(s) being manifested in some physical behaviour(s). Numerous interacting mental and physical behaviours which support performance in the patient-handling domain were identified in Study 1. Examples of mental behaviours are the acquisition and interpretation of information concerning a patient's state, or the provision of information to the patient concerning what is going to happen to them. Such mental behaviours were supported and expressed in novices' physical behaviours of questioning a patient, reading a patient's notes, and explaining the sequence of intended handling events to them.

Structures provide the capability for a person's physical and mental behaviours. Physical structures might be, for example, biomechanical, physiological, or neurological; mental structures comprise representational schemes, i.e. knowledge. The limits of human structures determine the limits of the behaviours they might support. Examples of abstract structural limits are completeness of knowledge of the domain, or capacity for information storage. Examples of physical structural limits are muscle strength and body size.
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The general research problem is one of ineffective training. Training is not explicitly defined by Dowell and Long (1989); however, given the concepts of actual and desired performance, training may be conceptualised as:

'the development of physical and mental structures in the human component of an interactive worksystem to enable the IWS to achieve a desired level of performance'.

The effects of training can be expressed as a change in actual performance, the overall goal of training being to reduce the gap between the actual and desired levels of performance of the novice working in a target domain.

Consequently, the general problem of ineffective training in patient-handling can be expressed, using the framework. Performance of the worksystem in one situation, the classroom, does not necessarily support performance of the worksystem in another situation. This can be attributed to the failure of the training programme to support the adequate development of physical structures, mental structures, or both, in order to support desired task performance.

In general terms, ineffective training will be associated with a sub-optimal worksystem performance, in which the actual level of performance is below the desired level. A solution to the problem is required which provides more adequate support to the development of physical and mental structures which are, in turn, able to support the
behaviours and performance required in the domain of patient-handling.

Based on the findings of Study 1 the patient-handling problem can be characterised as a complex planning task. Although the idea of a plan is evident in theories grounded in Miller et al's (1960) ideas, such theories cannot prescribe intervention because the relationship between structures and behaviours and performance is missing. This deficit may be remedied by the ergonomic framework just described. However, to support the prescription of an enhanced training programme, the ergonomic framework needs to be considered alongside a modelling framework that provides a specification of the relationship between knowledge representation, plans and behaviour in the complex world of patient-handling.

4.5.2 The ergonomic framework and a specific modelling framework

The model needs to support reasoning about the differences observed between novices' and experts' behaviours in the workplace. For example, it needs to explain novices' relative inability to organise and schedule the task, and their inability to respond to unexpected events.

To help the model support generalisation of any prescribed solution, the results from Study 1 were used to generate a set of assumptions on which the observed behaviours were presumed to be based. The assumptions were as follows:

1. There is a process associated with organising (planning) the task and specifying what needs to be done initially and throughout the task.
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2. There is a set of behaviours concerned with forming a representation of the state of the world with respect to the task.

3. There is a set of behaviours concerned with executing the task.

4. The task behaviours are controlled in some way and may overlap temporally.

From these assumptions it appears that the model needs to characterise the relationship between the task behaviours of organising (planning), perceiving, and executing, and to relate these to an overall controlling behaviour.

One previous attempt to model behaviour in complex environments has resulted in the development of a framework for a model of multiple activity and control - the MMAC modelling framework (Smith, Hill, Long and Whitefield, 1992a; 1992b). In outline, this framework rests on the premise that a critical determinant of a worksystem's (i.e. either the trainer + trainee, or else the trainee with or without lifting aid) effectiveness is how decisions are made about the selection and sequencing of behaviours. The framework postulates that an adequate view of the latter requires a view of planning and control behaviours and of their relationship with execution and perception behaviours. Planning is defined as the specification of how tasks are to be accomplished, whereas control concerns the sequencing of behaviour.

In the context of solving the specific research problem, the design of an enhanced training programme theoretically, requires one of two approaches. These are not necessarily mutually exclusive. The programme must provide enhanced knowledge to support
physical behaviours, which enable desired performance. Such enhancement may be provided by physical training. Additionally or alternatively, the programme must provide enhanced support to mental behaviours, such that mental behaviour supports desired performance. Such enhancement may be provided by mental training.

4.6 Training

On an ad hoc basis, numerous enhancements to the training programme may be proposed. For example, students might be offered programmes which are differently organised either over time, or in terms of their instructional style. The following section recruits aspects of the training literature, to permit specification of the possible solution space and to support the design of a programme which might, on rational grounds, be presumed to be an improvement. It aims to provide the reader with sufficient background information to be able to appreciate the types of enhancement which could be investigated for their effects on the research problem.

4.6.1 Definition of training

The Manpower Services Commission (MSC) defined training as

'A planned process to modify attitude, knowledge, or skill behaviour through learning experience to achieve effective performance in an activity or range of activities'

(Manpower Services Commission 1981, p62)
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Similar definitions are echoed by others (Department of Employment, 1971) and serve to emphasize that training is not only about learning per se, but about such learning being reflected in enhanced performance of a specific task. In terms of the framework, this definition loosely embraces the required knowledge support but leaves implicit the need for training to support the development of appropriate structures.

Definitions such as the one provided by the MSC are useful if taken to imply that the 'planned process' can be embodied in a tractable form by, for example, a training programme, rather than being an open-ended activity reliant on an individual's experiences. The notion of a planned process is presumed in the following discussion, as it enables the definition to be expanded, so that the content of the training programme can be differentiated from the training method, the trainee, and the trainer, each of which may affect the design of the training programme.

4.6.2 Factors affecting training design

To consider ways in which the effectiveness of the training programme can be enhanced, it is necessary to identify the principal factors influencing programme design. Four factors will be considered:

a) the trainee
b) training content (knowledge to be imparted)
c) training methods (with or without training materials/aids)
d) the trainer

An effectively designed training programme supports but does not mandate effective
training. The latter requires information to be passed from a source (the trainer) to a recipient (the trainee), in such a manner as to be received by the recipient and be available for subsequent use. To fulfil these requirements, the trainer must possess the information to be transmitted, must intend to pass it on and must be capable of doing so. The trainee must be able to receive the information, must want to do so and must be able to use it subsequently to achieve a desired performance. If the trainee satisfies these requirements the knowledge imparted (programme content), the methods used, and the mode of delivery must support the performance desired of the recipient. The assumption made in this thesis is that both the trainer and the trainee are able and motivated, to give and receive training respectively. On commonsense grounds and considering the findings of Study 1, both of these assumptions seem reasonable.

The training must include the types of knowledge required to support a trainee's performance of the tasks. This knowledge must be structured into appropriately sequenced chunks, which can be adequately acquired by the trainee. For example, in patient-handling training, there is a minimal requirement for the trainee to acquire knowledge about what to do and how to do it. This coexists with a requirement to order the information in a manner compatible with its use, so that, for example, preparing to lift/handle is taught prior to actual lifting/handling, and simpler manoeuvres are taught before complex ones.

As the principles underpinning the content of patient-handling training programmes are reasonably well established, the aspect of design which will be considered in more detail.
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is training methods. Omitted from the following discussion is reference to the media by which training is given, for example, lectures, tutorials, videorecordings, as these are generally considered of secondary importance from a training design perspective (Patrick, 1992 p 274).

4.6.3 Training methods

Discussion of the many training methods which exist is hampered by the fact that the methods are not clearly definable (for a more comprehensive discussion, see Reigeluth, 1983). A major problem also arises in terms of understanding how different methods work, given that a particular method may have multiple effects, for example, it may both support new learning and strengthen old learning. The specific training programme needs to offer improved support to mental behaviours. According to Dowell and Long's (1989) framework, it can achieve this by the development of improved mental structures.

The training methods present in the training programme can be considered first, with respect to their presumed main effect upon knowledge support and secondly, in relation to their effects on mental, physical, or mental and physical structural development. Mental structural development is the development either of new ways of organising knowledge or the strengthening of existing knowledge organisation structures. Similarly, physical structural development represents either the recruitment of new physical structures or else the strengthening of previously used structures.
Support to the development of mental and physical structures can be conceived in two ways. First, in terms of repetitive use of structures, such that by responding they are established and developed. Secondly, in terms of changing the way in which structures are used, so that different responses are required, leading to the acquisition of a more flexible set of responses.

Many of the training methods are used to varying extents and at various levels of formality within the design of patient-handling training programmes in general. The training programme includes reasonably extensive use of feedback, demonstration, and physical practice, and less extensive use of analogies, mnemonics, and whole vs part-task training. The following discussion considers the methods used in the specific training programme (STP), in the context of the findings of Study 1, in order to identify more clearly the requirements for a solution.

4.6.3.1 Mental structural support

a) Knowledge of results - Feedback

Allowing a trainee to perform a task and then providing information about the correctness of the action constitutes the provision of knowledge of results (KR). A substantial literature exists concerning how and when to provide KR to maximise learning (for reviews, see Adams, 1971; Salmoni, Schmidt and Walter, 1984). Knowledge of results comes, not only from extra information provided to the performer, but also from the visual, auditory, and proprioceptive information associated with normal performance of the task. Annett (1969) formalised this distinction by naming extra information, not
available in the normal (i.e. non-training) task situation, extrinsic feedback, in contrast to intrinsic feedback, which is information available in the non-training situation.

Both types of feedback exist within the STP. In terms of the framework, KR is the means by which the learning worksystem acquires some notion of the assessment of performance. Intrinsic feedback includes the trainee's perception of, for example, a patient's position or state of pain. Extrinsic feedback, for example, information concerning the adequacy of a patient's final position, is provided by the learning worksystem itself, via the trainer and via the trainee's peers. However, its provision is on an ad hoc basis, raising the question: Does the specific training programme contain sufficient feedback?

In Study 1, novices' classroom performance scores were adequate, so it seems reasonable to conclude that those aspects of the programme concerned with the establishment and refinement of knowledge support, including KR, were satisfactory. However, one of the problems in designing extrinsic feedback is that it may enhance performance but not effect learning, leading to a performance decrement when feedback is withdrawn (Patrick and Mutlusoy, 1982). It is possible that novices' poor workplace performances reflected an undue reliance by the learning worksystem on feedback, which was not available to the real world worksystem.

Guidance can be considered a form of high level feedback. However, it differs from extrinsic feedback in terms of the timing of information provided to the trainee. Whereas extrinsic feedback is provided after action, guidance conveys advance information.
Guidance may be verbal or physical as, for example, when constraint is imposed on a trainee's movements. Although physical guidance can be as, or more effective than feedback as a training method (Holding and Macrae, 1964), this appears only to be true when the training and test conditions are similar. Thus, Stammers and Patrick (1975) suggest that the training and test conditions must be similar in terms of the intrinsic (proprioceptive) feedback available to the trainee. Within the STP, guidance does not formally exist but may occur on an ad hoc basis. In the learning worksystem, the objects to be moved are 'model' patients who may provide very different proprioceptive feedback to the 'real' patients in the application worksystem. This perhaps suggests that there is little basis for enhancing the specific training programme by the addition of more low level guidance. However, it does not preclude the use of what might be called higher level guidance, achieved for example by instructing students in strategies that they might use.

b) Demonstration

Demonstration as a training method originated in the ancient notion of apprenticeship. More recently it has developed from the areas of motor skill psychology and from social and developmental psychology. It forms a significant part of the STP and involves providing trainees with visual information in advance of action. Theoretical ideas developed by social psychologists prompted further investigation of the role of demonstration in motor learning. This led to Bandura's (1977) suggestion that, by observing a demonstration, a trainee can develop a cognitive representation which can be used to guide behaviour. For a review of the role of demonstration in motor skill learning, see Adams (1987) and for consideration of the use of demonstrations as training
techniques, see Sheffield and Macoby (1961).

Demonstration can be presumed to provide the learning worksystem with a view of desired performance. It also provides preliminary knowledge structures which can be subsequently refined, if novices' perceptions are accurate enough to support such refinement. On the basis of novices' adequate classroom performance scores, the demonstration component of the STP may be presumed to be adequate.

c) Analogies

By definition, an analogy highlights the similarities between two situations, ideas or actions. Therefore, it provides a basis for understanding something 'novel' in terms of something 'old'. In the last decade it has been suggested that much learning is supported by analogical reasoning (Rumelhart and Norman, 1981). In the STP the only analogy used is, 'don't use your back like a crane'. Presumably, this provides some support to the learning worksystem regarding the establishment and organisation of knowledge and therefore the development of mental structures. However, in an analysis of 216 analogies used in science, Curtis and Reigeluth (1984) highlighted the need for an analogy to be accompanied by an explicit description of how the analogy was relevant and should be used. This is missing from the STP. Curtis and Reigeluth (1984) suggest that such neglect may lead the trainee to focus on the differences between two situations rather than the similarities. It may be that the STP makes insufficient use of analogies. Equally, it may fail to describe their usage adequately, such that the novices perceive the learning worksystem very differently from the real world worksystem. As Curtis and Reigeluth (1984) point
out, it is uncertain when analogies are most useful to the learner and when they may become confusing and unclear.

d) Mnemonics

Mnemonics provide a way of associating new information with old information in a meaningful way, in order to facilitate its recall. Numerous classes of mnemonics exist, (for details, see Braby and Kincaid, 1978). However, Patrick (1992) advises caution in their use. He argues that mnemonics should only be used when there is little intrinsic organisation available in the training material, and suggests that trainees might be lured into using mnemonics rather than pursuing a deeper, more meaningful understanding of the material. Within the STP, the learning worksystem is provided with the mnemonic, BACK FIRST (see Appendix 1) which should afford support to both the retrieval of knowledge and to the development of mental structures. However, novices' poor workplace performances may suggest that Patrick's caution has not been heeded, and imply that mental structures inappropriate to the real world worksystem may have been developed.

e) Part and whole-task training

That part task-training potentially affords support to the development of mental as well as physical structures reflects the previously mentioned difficulty of classifying training methods. Furthermore, it is difficult to predict whether part-task training will mainly affect physical or mental structures.
4.6.3.2 Structural support - physical

a) Repetition - practice

Physical repetition is a common component of many training programmes. Important practical questions concern the length and spacing of sessions. The published literature emphasises almost exclusively the latter, with substantial debate over the merits of massed and distributed practice (e.g. Bilodeau and Bilodeau, 1961). The consensus is that distributed practice is superior to massed practice (Shea and Morgan, 1979), although the most marked difference between the two types occurs during training, when massed practice produces worse performance. Subsequently, the difference in performance of trainees who have undergone different schedules appears to be reduced (Bilodeau and Bilodeau, 1961).

Practice may be presumed to be the means by which the learning worksystem acquires and refines motor knowledge structures and develops physical structures. Distributed physical practice appears in the STP, although little attention has been paid to its design. Nevertheless, the novices in Study 1 did not report undue physical workload. Presumably this indicates either, that the practice schedule offers adequate support to the development of appropriate physical structures, or that the physical structures are, in any case, adequate.

b) Part and whole-task training

Whether training should focus on the whole of a task or just part of it has long been debated (for a review, see Stammers, 1982). Although it is generally agreed that the
divisions introduced by part-task training should coincide with the natural ones made by trainees, this is not especially helpful in practical terms for two reasons. Firstly, because of the difficulty in predicting a trainee's conceptualisation of a task and secondly, because this conceptualisation will change over time. A further practical problem with part-task training is that trainees may have difficulty in reassembling the parts to allow performance of the whole task.

Within the STP, the use of part-task training is not explicitly defined. However, in practice the trainer often suggests that trainees may, for example, practice the 'hold' associated with a particular manoeuvre before attempting the whole manoeuvre, or may practice moving a person to the edge of the bed before transferring them to a chair. Such breaking down of the task offers a means of changing the responses required from the physical and mental structures and so may provide support to the development of these structures. However, given the difficulties mentioned above, the inclusion of more part-task training does not seem to be the most fruitful way of solving the specific problem.

4.7 Summary and conclusions

Study 1 suggested that it was novices' mental behaviours which needed more support in order to bridge the gap between classroom and workplace performance. The preceding discussion has shown that the STP may be defective in terms of the support afforded to mental structures. It has drawn attention to the need for a rational approach to the design of an effective programme. Such an approach has been initiated by locating the research
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problem within a framework. To begin to support reasoning about possible enhancements to the specific training programme, there is a need to detail a specific model of the cognitive and physical behaviours evidenced by the novices. This is the concern of Chapter 5.
Chapter 5

MODELLING THE RESEARCH PROBLEM: DEVELOPING A MODEL FOR A SOLUTION

5.1 Chapter overview

This chapter develops the theoretical stream of the work. Chapter 4 explained that a variety of existing psychological models fail to support the design of training which exploits more effective transfer. It identified the MMAC modelling framework as likely to offer support to a more appropriate model, which is more able to offer support to transfer. This chapter begins by detailing the MMAC framework. The second part of the chapter describes a specific model derived from the MMAC framework to allow it to be used in modelling the specific research problem. The final part of the chapter considers the behaviours observed in experts' and novices' in Study 1, in the context of the proposed model.

5.2 Introduction

To recap, the model's requirements include an ability to characterise the abstract and physical aspects of complex tasks involving concurrency, and to capture the dynamic planning aspects of such tasks. In satisfying these requirements, the model has two general purposes. First, it is required to support reasoning about interventions to support the design of more effective training programmes in patient-handling, such that the difference between novices' and experts' performances is reduced. Second, it is intended to support generalisation of the identified features of non-compliance and of the prescribed solution.
More specifically, the MMAC modelling framework provides a conceptual basis to support the redesign of training programmes for patient-handling, by characterising the relationship between the planning, controlling, perceiving, and executing behaviours of experts and novices in the patient-handling domain. The relationship between the ergonomic framework described in section 4.5 and the MMAC modelling framework is depicted in Figure 5.0.

5.3 MMAC modelling framework

5.3.1 Background

Central to the MMAC modelling framework is the observation that many workplace situations involve multiple task work at some level. That is, a person, as part of one or more worksystems, is required to perform several distinct, but temporally overlapping tasks, each of which generates different and potentially competing requirements for worksystem behaviours. Although multiple task work has been studied previously (Damos, 1991; Wickens, 1992) most of this work has been concerned with the simultaneous processing of relatively predictable sources of stimuli over a relatively short time. This can be contrasted with workplace situations where several tasks may be unpredictable and as performed over relatively long, overlapping periods. The complex combination of temporal interleaving and unpredictability is another reason for using the
Figure 5.0
Relationship between ergonomic framework and MMAC framework
(Dowell and Long, 1989)
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MMAC modelling framework in preference to a model based on, for example, short term knowledge representations which may be better suited to explaining simple, serial behaviour.

Smith et al (1992a) argued that, to adequately account for the way a worksystem organises and temporally structures its behaviour, what is required, is a view of planning, control, execution, and perception behaviours. Furthermore, a view of the relationship between planning and control behaviours and execution and perception behaviours is needed. In advancing this argument, Smith et al followed other authors (e.g. Wilensky, 1983; Suchman, 1987) and challenged the traditional notions of planning, in which plans are conceived as complete, fully elaborated specifications of executable behaviours, which a person works through step by step (Miller et al, 1960).

Like Smith et al (1992a), Ambros-Ingerson (1986) also discusses the situation where the environment in which planning occurs, is either too complex to be modelled by the planner in the fully elaborated manner suggested by Miller et al (1960), or else, it is too unpredictable for a fully elaborated plan to be beneficial. 'Only in static, simple, and predictable task environments can fully elaborated planning precede execution' argues Ambros-Ingerson (1986). Hence, in other situations, plans may be partial (in that they may only specify some of the behaviours to be implemented) and/or general (in that some behaviours may be specified generally and not at a level that is executable).
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For example, in health care environments the requirement is for plans which are not fully elaborated, that is, they do not completely specify how an overall goal is to be achieved. This requires the person to control the behaviours in terms of their sequencing, and in this way, be able to respond to changing environmental requirements. Smith et al (1992a; 1992b) suggest that in these types of situations, plans serve as resources for guiding control decisions, rather than as providers of a precise specification of the behaviours to be executed. If a plan acts as a resource, it need not be limited to specifying behaviours, but alternatively may specify required states of the task. Given these options, plans that function as resources for guiding rather than specifying behaviour cannot ensure that goals will necessarily be achieved.

To respond to unexpected events, a worksystem must first be able to perceive the change in state of the environment. It must also be able to suspend sequences of execution behaviours and update its plans appropriately. Consequently, control decisions are needed, not only to select execution behaviours, but also to switch between execution, perception, and further planning behaviours. The MMAC modelling framework meets many of these requirements as the following description of its components verifies.

5.3.2 Components of MMAC Modelling framework

This section will describe the original MMAC modelling framework in detail. By using examples drawn from the specific MMAC model of planning and control of office administration, it will aim to demonstrate the utility of the model in reasoning about
behaviour in complex situations. Only those aspects of the model which are relevant to its subsequent use in modelling the research problem will be described (for a comprehensive discussion of MMAC, see Smith et al 1992a, 1992b; Hill, Long, Smith and Whitefield, 1995).

The MMAC model comprises four processes which support four types of abstract behaviour. These processes act on two declarative knowledge representations, namely knowledge-of-tasks, and plans (procedural knowledge supports the behaviours themselves directly). Each process has parameters which are changeable and which determine the behaviours which the process supports. As depicted in Figure 5.1 interactions between the processes and representations are described by:

1. 'write arrows' - where a process changes either the parameters of another process or the contents of a representation
2. 'read arrows' - where a process reads the contents of a representation

The model postulates a set of four abstract behaviours, each of which is supported by abstract structures. Planning and control behaviours (and supporting structures) of a person and device(s) of the interactive worksystem, when they interact with the perception and execution behaviours (and supporting structures), carry out work.
The four abstract behaviours will be considered in turn:

1. **Planning behaviours**

These are the behaviours which specify what and/or how tasks will be accomplished in terms of the required object transformations and/or required worksystem behaviours, respectively. Planning behaviours update the contents of the plan representation based on their reading of both the contents of the knowledge-of-tasks representation and the existing contents of the plan representation. Two types of planning behaviour are conceived: plan elaboration and plan scheduling. Plan elaboration behaviours are those concerned with the specification of tasks and/or behaviours in greater detail. Thus, the secretary who merges tasks by, for example, grouping a pile of messages and dealing with them all simultaneously, can be said to have formed a plan which identified that identical behaviours were required to deal with objects which related to different tasks. Plan scheduling behaviours are concerned with the specification of when tasks and/or behaviours are to be carried out. For example, the secretary who arranges physical objects on her desk as a reminder of what remains to be done is demonstrating plan scheduling behaviours.

2. **Perceiving behaviours**

These are those behaviours whereby a worksystem detects and records, but does not interpret, the value of relevant objects' attributes within a domain. An example is recognising the amount of mail in a post tray.
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Figure 5.1

Abstract Structures of MMAC
(Smith et al, 1992a, 1992b)

Key:
- Read Arrow
- Write Arrow
3. Executing behaviours

Execution behaviours are those which carry out the work of a worksystem directly by transforming the values of domain objects' attributes, e.g. the typing of a letter or the answering of the telephone.

4. Controlling behaviours

These are behaviours which select the behaviours to be carried out next at any given moment. They involve more than just reading off the next behaviour from a complete and fully elaborated plan. Control behaviours set the parameters of the planning, perceiving and executing processes based on their reading of the plan representation and the knowledge-of-tasks representation. By parameterising the processes, control behaviours configure the particular behaviours supported by those processes.

On the basis of a small empirical study of office administration work, Smith et al (1992a) suggest several methods by which control behaviours (CB) may determine switching between different behaviour streams, for example, switching from perceiving behaviours to executing behaviours. These methods include the following:

a) CB may start and finish a behaviour stream at the very beginning and end of a task respectively

b) CB may stop a behaviour stream at a natural break in the task and later may continue from the point of stoppage
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c) CB may suspend a behaviour stream at a non-natural break in the task and later may resume the behaviour from the point of stoppage

It seems reasonable to presume that similar methods and possibly additional ones may control behaviours in other domains such as patient-handling.

Two types of representation exist within the model:

1. Plans

These are the actual specifications of what and/or how tasks will be accomplished in terms of state changes of domain objects and/or of the required behaviours. Plans are formed and updated in response to information received through planning behaviours.

2. Knowledge-of-tasks

An important subset of the total knowledge people possess is task knowledge. According to Johnson (1992), task knowledge includes knowledge of the goals of the task, the procedures (strategies) required, actions and objects. It is widely assumed that people structure the knowledge about tasks that they have previously learned and performed in a given domain (Kieras and Polson, 1986). A further assumption is, that as people gain experience in performing tasks, knowledge structures develop and are applied to future task performance in a dynamic way. The development of the knowledge structures is presumed to be in line with more efficient recall and processing and hence, enhanced performance of a task.
The knowledge-of-tasks representation contains the state of domain objects and of the environment. It is formed and updated in response to information received through perceiving behaviours.

The relationship between the representations and the processes of the existing MMAC modelling framework is shown in Figure 5.1.

5.3.3 Conclusions

The MMAC modelling framework provides a means of reasoning about behaviour in complex environments. By virtue of its representational structures, it provides a general means of relating the knowledge a person has to the behaviours they produce. However, the model was neither developed nor used in the context of transfer of training. Hence, to assess the utility of the model with respect to supporting reasoning about ways of enhancing patient-handling training for physiotherapists, the format of the knowledge held in plans and in the knowledge-of-tasks needs to be related to the knowledge which the patient-handling training programme aims to deliver, which the novices acquire, and which the experts have. This necessitates firstly, representing the observed behaviours of novices and experts within the MMAC framework and secondly, relating this to the presumed knowledge structures of novices and experts.
5.4 Using the MMAC framework to model patient-handling

This section describes the use of the MMAC modelling framework, in the context of the specific research problem of an ineffective training programme for patient-handling tasks. As a first step to reasoning about ways of enhancing the training, it is necessary to assess the utility of the MMAC framework to characterise the differences between the behaviours observed in novices and experts.

The domain of patient-handling is one which exhibits different types of complexity. Thus, it may require concurrent streams of behaviour and may be unpredictable. The complexity of the environment is exemplified by the temporal overlapping of many aspects of the task. For example, communication with a patient may overlap with moving a locker, observing a patient's state may overlap with reading his/her charts. Equally, explaining to a patient what is happening to them may precede a manoeuvre and be continued intermittently during the manoeuvre. Although the overlapping aspects may be performed in a near-simultaneous manner, they continue for different lengths of time. Similarly, several patients may be treated at once with the handler moving to and fro between them. The environment may also be unpredictable. For example, when a therapist appraises a patient, plans and decides what to do at the beginning of the session, a patient's state may suddenly change part way through the manoeuvre. Thus, if a patient faints, an unexpected change in a therapist's originally planned behaviours is required. Indeed, in Study 1 twelve unpredictable events occurred, and whereas all of the experts responded adequately, only two out of seven novices produced an adequate response.
From the specific data concerning novices' and experts' behaviours, two sets of knowledge representation structures were postulated. These were considered to be acted upon by four abstract processes enabling support of four behaviours.

The knowledge representations were as follows:

1. **Domain knowledge (knowledge-of-tasks + environment)**

   The knowledge-of-tasks representation comprises a set of hierarchical knowledge structures representing the domain objects, their attributes and the desired changes in these attributes. High level knowledge is knowledge which supports the high level attributes of domain knowledge, e.g. need to relocate patient. Low level knowledge supports low level knowledge attributes, e.g. patient's right knee has a flexion contracture.

   Domain knowledge includes all the knowledge representing domain objects, their attributes and the desired change in these attributes. It also includes representation of the physical behaviours of the worksystem, e.g. self knowledge, i.e. knowledge representing the handler's own body position and desired changes in it.

2. **Plans**

   Plans comprise a coherent set of hierarchical structures including memory and attentional structures. The findings of Study 1 suggested that the main difference between novices and experts related to their planning behaviours. For example, experts demonstrated better preparatory behaviours. They were more likely to clear the workspace adequately, to
position the bed, and to ensure that the patient was free to move. On this basis the MMAC framework was modified to produce a model of multiple activity control in patient-handling - the MMAC-PH model - which includes a more differentiated view of plans, in which a clearer relationship between domain states and behaviours is postulated. This is needed to facilitate characterisation of the problem of ineffective transfer. In relation to medical reception tasks Hill et al (1995) distinguished three types of plans. However, in the MMAC-PH model, plans are partly concerned with the state changes of the domain which are required to achieve a particular goal, and partly concerned with the specification of behaviours. The set of plan structures concerned with the state changes of the domain are conceived as the goal structures. The set of plan structures concerned with the specification of behaviours constitute the behavioural structures.

**Goal structures**

At a high level, one goal might be, 'to achieve a lifted patient'. This goal could decompose into sub-goals, for example, assessed patient, prepared workspace, each of which can be further decomposed. The interleaving of tasks in the patient-handling domain plus the fact that the trainee may, in part, behave in direct response to the environment, short circuiting any form of plans, means that the plans, at all levels may only be partially elaborated.

**Behavioural structures**

Plans are also concerned with the specification of behaviours, e.g. lift patient. Behaviours can be conceptualised at different levels. For example, the behaviour of, 'lifting the patient'
may decompose into, 'positioning the patient' and, 'positioning the therapist'. Two or more unitary behaviours may be linked together into a procedure. For example, applying the brakes to a wheelchair and asking an assistant to hold it may be linked to form a procedure, 'stabilise wheelchair'.

Any given goal state may be served by only one behaviour or procedure, by more than one behaviour or procedure, or by several behaviours or procedures. Similarly, any given behaviour(s) or procedure(s) may satisfy one or more goal states.

At a higher level within the plans, are the specification of planning and control behaviours which abstract over both the goal and behavioural structures. The plans specify the sequence of the goal states and behaviours and also specify how to sequence the procedures and unitary behaviours.

The processes are as follows:

1. Controlling

Controlling is the sequencing of perception, planning, and execution behaviours, e.g. reading a patient's charts notes before proceeding, communicating with a patient followed by or interleaved with organising the workspace, moving a wheelchair into position before attempting to assist a patient to move.
2. Planning

Planning is the construction of plans. A plan is defined as the conscious (intentional) representation of the specification of either the required domain states or specification of the intended behaviours (including planning and control behaviours).

Examples of planning occur when:

a) a handler organises the workspace and decides what to do (e.g. which handling manoeuvre to carry out), evaluating possible approaches, e.g. use of a lifting aid or not, assisting the patient to roll or rolling him with the help of another person.

b) a handler updates and responds to changes if something unexpected happens once the task has begun, e.g. if a patient slips or faints, if an intravenous drip becomes trapped.

3. Perceiving

Perceiving is the acquisition of relevant and irrelevant conditions of the domain and of the behaviour of the interactive worksystem with respect to domain changes.

Examples of perceiving occur when:

a) a handler appraises the initial conditions, state of the object, for example, how heavy the patient is, what is a patient's likely ability and/or willingness to cooperate and/or help with the manoeuvre, the amount of space available to
move in.

b) a handler detects a patient's state, changes in state throughout execution of the task, for example is a patient heavier or more awkward than anticipated, does his/her state change, e.g. is (s)he about to faint or lose balance.

c) a handler appraises his/her own state, e.g. his/her own position, level of risk.

4. Executing

Executing is the transformation of domain objects via implementation of the behaviours specified by the plan.

Examples of execution are:

a) verbal communication with patient asking him how he is, explaining what is going to happen and how (s)he is required to assist.

b) positioning self to enable initiation of handling manoeuvre.

c) adjusting hand position to get a better grip on a patient.

d) lifting a patient

The MMAC-PH model for patient-handling is shown in Figure 5.2 and the relationship between goal and behavioural structures existing in the plans is depicted in Figure 5.3.
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Figure 5.2

MMAC-PH

Key:

Read Arrow

Write Arrow

PHBS* Patient Handling Behavioural Structures

PHGS* Patient Handling Goal Structures

* Indicates MMAC Extension
Figure 5.3 shows an example of the relationship between achievement of a certain part of the goal structure and the recruitment of behaviours. For example, in the diagram, the goal 'Achieve lifted patient' can be decomposed into 'Achieve positioned lower limbs' G2, 'Achieve positioned upper limb G3. In satisfying G2, a procedure Proc 1 may be recruited. Proc 1 comprises three behaviours: B1, move foot; B2, move slippers; B3, check skin condition. As indicated satisfying G2 may also necessitate recruitment of an atomic behaviour, e.g. B5, bend knee.
5.4.1 The MMAC-PH model and teaching effectiveness

The training programme appears to support the acquisition of:

a) goal states; $G_{i,n}$ (e.g. achieve lifted patient) and

b) procedures; $\text{Proc}_{i,n}$ (e.g. different ways of lifting) and

c) atomic behaviours; $B_{i,n}$ (e.g. move slippers)

In each case $n$ is an indefinite number specified by the variety of goal states or behaviours possible. The high level goal states are those concerned with specifying in a fairly general way what is to be achieved. The lecture components of the training programme can be presumed to support the acquisition of generic goals, procedures and behaviours. In Study 1, the lecture parts of the training programme were reported to be adequate, suggesting that novices have few problems acquiring the generic knowledge.

The training programme also supports, by the practice elements of the programme, the translation of high level generic knowledge into a few specific instances. The specific training programme can be viewed as offering support to the formulation of a set of generic plans. The rules governing this formulation can be considered to be the default structure. This structure is presumed to be recruited when a trainee is required to perform in a novel situation.

Performance of a task occurs by the execution process implementing procedures and behaviours which have been selected from the available repertoire, to satisfy the specified goal structure. Each level of the goal structure may be served by a different permutation.
of behaviours. The research problem can be expressed as one of how to make the generic knowledge to be conveyed in training programmes more generalisable, i.e. so that it supports a wider range of specific instances. This presumes, of course, that the training programme has not left the trainee deficient with respect to particular atomic behaviours.

Planning and control behaviours are concerned either with specifying and sequencing behaviours, procedures, and goals, or else with the translation of knowledge from high to low states. It seems reasonable to suggest that a solution which offers support to planning and control behaviours should support the formulation of appropriate goal structures, which are able to recruit appropriate behaviours in non-taught situations. In other words, supporting planning and control behaviours should facilitate the application of the generic knowledge.

5.5 Knowledge structures

By comparing novices' knowledge structures with the structure of knowledge intended by the training programme, some indication should be acquired of the need for support for more effective training. Further indications should be obtained from comparison of the presumed knowledge structures of novices with those of experts. This section considers the structure of knowledge which the training programme aims to deliver. It then places this in the context of the specific data from Study 1. This allows consideration of the differences between experts and novices in terms of their presumed knowledge.
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representation structures (plans and knowledge-of-tasks) and their behaviours.

5.5.1 Structure of knowledge training programme aims to deliver

In general terms, given that the research problem is one of poor transfer of learned skills, the criteria for postulating the structure of the knowledge which the training programme aims to deliver are, that it is able to encapsulate the structure of:

1. training programmes in general, i.e. the structure postulated is not idiosyncratic to the specific training programme
2. the presumed knowledge of novices including deficiencies and non-deficiencies
3. the presumed knowledge of experts including deficiencies and non-deficiencies

By distinguishing the presumed knowledge of novices and experts, a foundation is laid for subsequent prescription of relevant interventions to enhance the training programme.

The knowledge required to perform a task is commonly assumed to be represented as multiple hierarchies with knowledge at different levels of generality. Each level of the hierarchy can be viewed as being potentially complete, in terms of its ability to describe its application without reliance on any other level. Within training programmes generally, a similar hierarchy of knowledge representation can be suggested and indeed hierarchical task analysis (Annett and Duncan, 1967) was developed for training. The nature of the relationships between different levels of different hierarchies can vary. For example, a
'shoulder' lift has a 'TYPE' relationship to the higher level description, 'Types of patient lift'. In comparison, the bones of the spine exist in a 'PART OF' relationship to the 'anatomy of the spine'. In summary, the knowledge contained within the training programme aims to be appropriately structured such that it may be appropriately acquired by the student.

Cognitive neuroscientists concerned with movement often describe three inter-related levels of computation. Following this view, if a simple three level hierarchy is assumed, it seems feasible that aspects of a programme may support the acquisition of predominantly generic, high level representations. Only if converted to lower level representations and instantiated will these high level representations offer support to overt behaviour. Similarly, aspects of a training programme may support the acquisition of predominantly low level representations. Only if converted to higher level representations and generalised will these low level representations offer support to overt behaviour, other than that previously instantiated in the classroom.

The three levels of representation may be considered to be acted upon by a single process of implementation, whereby the high level representation is converted into a lower level, more easily applied form of knowledge. Alternatively, the low level representations are converted into a higher level, more generalisable form of knowledge. In both cases, the student has to generate the missing levels of representation.
A low level representation is always necessary for physical behavioural instantiation. However, if a training programme only supports the acquisition of low level representations, then a student is unlikely to be able to generalise the knowledge and subsequently transfer it to support the performance of non-taught tasks. Conversely, a representation that is too high in level, would not be predicted to be readily able to generate representations at a sufficiently low level to support appropriate behaviours. Interestingly, Pheasant (1991p2g9) alludes to this type of situation when he compares the development of lifting skills to the development of a tennis serve. He points out that such skills can be taught procedurally using a, 'doing it by numbers' approach but explains that the levels of skill acquired in this manner are somewhat limited.

The next section aims to test this view and attempt to answer the question: 'What is the structure of knowledge in patient-handling training programmes?' Given that the patient-handling tasks analysed in the first study were believed to be representative of those carried out in health workplaces, sections 5.5.2 and 5.5.3 considers the findings of that study in the context of the MMAC model.

5.5.2 Presumed knowledge structures/specific model experts

In contrast to novices, experts perform adequately, if not ideally in the workplace, and their performances are significantly better than those of novices. Experts do, in general, select appropriate manoeuvres to reduce the load on the spine. Thus, they exhibit behaviours which are, at least partially, compatible with the training programme's aims of
producing a set of trainee behaviours which will reduce the likelihood of back pain.

The presumed knowledge structures of experts, are likely to be similar to those intended by the training programme, and are the knowledge structures it is hoped the novices would acquire. Unlike the novices, the experts' high level representations appear to support the formulation of multiple, appropriate, low level representations. In turn, these can support behaviour in different contexts. In other words, the quality of experts' high level representations is either better than that of the novices, i.e. there is better specification of the desired end state of domain, or else the translation process is better supported, or both.

In terms of the model, the experts seemed to show greater reliance on proceduralised knowledge with good heuristics, and were more able to adapt their behaviours to the workplace. For example, when performing a patient transfer, constraints imposed by additional objects attached to the patient did not seem to markedly impair the experts' performance whereas the novices' performance was very sensitive to these added complexities (see for example, Behaviour B14, Table 3.2).

The experts appeared to demonstrate adequate high level plans and adequate planning. For example, they spent time initially deciding what to do and were more able to respond to unexpected events, and to accommodate objects which do not appear in the training programme, e.g. drains, orthoses (see section 3.4.6 and Table 3.2). Behaviours such as
preparing the destination area (Behaviour B5, Table 3.2) suggested that the experts had thought through their whole plan.

In comparison to novices, the experts also appeared to evidence more adequate domain knowledge indicating that their perceiving process was more effective. There seemed to be a suggestion that there was less and differently formatted information in the experts' plans compared to the plans of novices. This may indicate that the translation process in novices may be impaired. For example, the tendency appeared to be for experts to create a crude plan expressed in terms of the sub-goals to be achieved but omitting irrelevant detail. In comparison, novices tend to focus on low level details so that their plans included some of the details of where the handler was to position his/her feet, where to position the patient's limbs, and what to say to the patient, all transposed more or less directly from the training programme.

Apart from demonstrating only partially elaborated initial plans, the experts also seemed to demonstrate more updating of their plans as they moved. For example, if it became apparent during the manoeuvre that it would be easier for a patient to be moved in a different direction, the experts were more likely than the novices to change their plans. The apparent updating of plans indicates that experts may have better control behaviours such that they are more able to interleave planning behaviours with perceiving ones.

To summarise, the experts apparently had better high level plans which were supported
by better perception. Because of this the experts were better able to generate low level representations to support behaviour in non-taught tasks.

5.5.3 Presumed knowledge structures/specific model novices

The specific data from the first study showed that novice performance of patient-handling tasks was adequate and appropriate in the classroom, but was inadequate and/or inappropriate in the workplace. Thus performance in the workplace was, at best, equal to that in the classroom, and was often inferior to classroom performance. Although two subjects achieved the same performance score in the classroom and the workplace, no subject actually achieved a higher score in the workplace. The difference in performance in the two situations, is attributable to the requirement for knowledge support being different. The nature of the difference can be attributed either to lack of knowledge or to a failure of implementation. Thus, from the training programme, trainees have acquired knowledge which is appropriate to support behaviour in the classroom, but inappropriate to support behaviour in the workplace.

To summarise, two theoretical possibilities exist regarding the deficient workplace knowledge:

a) Classroom knowledge is appropriate for the classroom but not for the workplace even if it is remembered

or
b) Classroom knowledge is appropriate for the classroom and for the workplace only if it is remembered and generalised.

It has already been suggested that the training programme supports the acquisition of a range of high to low level representations. Despite controversy over the, 'best' way of handling (e.g. Venning, 1988) the biomechanical principles on which the specific training programme is based are reasonably well established, making it unlikely that the knowledge is inappropriate to support behaviour in the workplace. This is not intended to imply that the knowledge provided by the training programme can always be instantiated at a high level of performance in the workplace. Clearly this is not the case, as often the physical constraints of the workplace preclude the use of a specific patient-handling manoeuvre, or the application of a specific behaviour, in precisely the manner taught. However, the actual knowledge provided by the programme, at the level which it is provided, is, in general, reasonably well founded.

Novices were able to produce the desired behaviours in the classroom but were, in the main, unable to do so in the workplace. Presumably, the training programme supports the acquisition of a set of low level representations which support behaviour in the classroom, but which cannot be generalised to support behaviour in the workplace. For example, novices are able to perform a shoulder lift/slide (which entails them facing a patient and positioning their shoulders in the patient's axilla) adequately in the classroom situation but are unable to do so in the workplace. This failure is usually a function of novices' inability
to configure either themselves or the patient appropriately, once the situation becomes more complex, as additional cues impact.

In terms of the three level hierarchical system of knowledge representation, it appears that the quality of the high level representations or of their translation to lower forms, may be presumed to be deficient with respect to supporting the formulation of low level representations, which in turn support behaviour.

Thus, the novices' behaviours showed reliance on predominantly declarative knowledge as they reverted either to what they knew before being trained, or else implemented the low level representations acquired during the training period. For example, novices may revert to dragging a patient, as they would have done before being trained. In other words, the novices failed to bridge the gap between their abstract knowledge and their physical behaviours.

In terms of the model, novices appeared to demonstrate a lack of high level plans and a lack of planning. Hence, they had difficulty in deciding what behaviours were necessary in order to achieve their goal so, for example, if a patient had a catheter or a splint attached, novices found it difficult to fit this into their overall goal of a moved patient (see section 3.4.6 and Table 3.2). Consequently, they tended to either become preoccupied with the catheter/splint, or else to ignore it (Behaviour B14, Table 3.2), suggesting an inability to use their knowledge to work out how to reconfigure their approach to the
task. Unlike the experts, the novices were unable to create appropriate sub-goals to reduce the difference between the existing state of the domain and the desired state. By failing to create appropriate sub-goals, it may be presumed that the novices fail to set up the right conditions to then select appropriate behaviours.

Novices also appeared to evidence poorly constructed plans, with poorly formatted domain knowledge. Hence, the amount of domain information which appeared to influence novices' planning seemed to be greater than that referred to by the experts, probably because it included much irrelevant information. For example, furniture and its arrangement within the workspace was often adjusted even when the patient was not to be moved out of the bed and the workspace arrangements did not influence the novices' ability to work. In the context of evidence which suggests that the structural properties of objects constrain the way in which actions (behaviours) are planned and controlled (Marteniuk, Mackenzie, Leavitt, 1988; Charlton, 1992) it seems plausible that this explains why the novices appeared to show less ability to plan and to perceive those aspects of the environment which are critical for the development of good plans which support changed behaviours.

5.6 Summary

This chapter has used the MMAC framework to develop the MMAC-PH model and has explained the use of the model in the context of the research problem. In so doing,
Chapter 5 has laid the basis for reasoning about possible solutions. These are discussed in relation to the model in Chapter 6.
Chapter 6

DEVELOPING A SOLUTION

6.1 Chapter overview

This chapter describes the development of a solution to the problem of ineffective patient-handling training via an enhanced training programme. It considers the relationship of possible solutions to the MMAC-PH model and selects cognitive training as the main solution to be investigated. Following a review of cognitive training, details of the informal work needed to develop the solution are reported.

6.2 Introduction

Chapter 2 documented a study which demonstrated the existence of a problem for novices engaged in patient-handling tasks, in transferring knowledge acquired in the classroom to the workplace. Particular reasons for the problem were identified, and comparison of experts' and novices' behaviours further clarified the nature of the problem. This chapter offers a rationale for a solution, by using the modified MMAC-PH model described in Chapter 5, to identify possible enhancements to the training programme. One of these enhancements is selected for investigation.
Chapter 6: Developing a solution

6.3 Developing a solution

The enhanced training programme attempts to provide novices with knowledge enabling them to more effectively transfer and apply knowledge acquired in the classroom to novel patient-handling tasks in the simulated workplace.

The possible manner in which transfer could be optimised is derived from predictions made by the model. The model represents knowledge in a hierarchial structure and thus postulates that transfer can occur in two ways: by instantiation from high level abstract knowledge, or by generalisation from low level non-abstract knowledge. Both methods of transferring knowledge, i.e. instantiation and generalisation, involve making some form of comparison between the existing knowledge and that required.

According to the model, the existing training programme supports the acquisition of a set of generic representations of patient-handling which are instantiated to support the behaviours required in a few, specific, instances. For example, the programme includes the general principles of getting as close to the load as possible and keeping the back as straight as possible. These general principles are then instantiated when a trainee practices a handling manoeuvre on a colleague acting as a 'model'. Thus the programme supports the acquisition of a generic goal and behavioural structure. It also supports a few specific instances in which a small set of specific behaviours (and procedures), which have been established by teaching and by experience are linked to the generic goal structure. This goal structure can be considered to be the default structure. For example, a trainee's goal
structure may include the goal, 'positioned self' which is linked to the behaviour getting as close to the load as possible. This behaviour may be inappropriately recruited, so that, for example, the student, in getting as close to the load as possible, traps a drip or drain which is attached to the patient. In non-taught patient-handling situations, trainees are postulated to revert to the default goal structure at least partially. The requirement is to enhance the training programme so that the generic goal structure representations can support a larger number of specific instances of patient-handling behaviours, and so improve patient-handling in the workplace.

Hence, transfer to a novel patient-handling task is contingent upon supporting firstly, instantiation from those generic plan representations acquired at a high level and secondly, generalisation of the low level representations. The generic representations are those supported by the training programme. The process of generalisation supports the modification of the generic representation so that it is able to support behaviour in a larger number of instances. Similarly, instantiation is the process by which the generic plan is used to support behaviour in a specific instance. According to the MMAC-PH model, the process of instantiation is embodied in planning and control behaviours, i.e. it entails acting upon the plan representation, to support the specification and sequencing of appropriate goals and behaviours.

To summarise, in terms of the hierarchical structure of knowledge in STP, the missing knowledge seems to be that:
Chapter 6: Developing a solution

a) supporting the translation of generic representations to representations which support behaviour in a specific instance, i.e. control knowledge which supports formulation of a goal structure appropriate to a particular situation.

b) supporting formation of a goal structure and goal structure/behaviour link leading to the recruitment of behaviours appropriate to a particular situation.

By providing the missing knowledge, according to the MMAC-PH model, support will be afforded to novices' planning. The model indicates that plan formation may be supported in two ways. Firstly, by supporting the perception process, and thus the structuring of the knowledge contained within the knowledge-of-tasks. Secondly, by providing direct support to those planning and control behaviours through which generalisation and instantiation are mediated.

Hence, an enhancement to the training programme is sought which will simultaneously combine the operationalisation of high level knowledge with the generalisation of low level knowledge. Working from the premise that the use of the plan in supporting behaviours will be strengthened by practice, it is suggested that an intervention is needed which allows the plan to be evaluated, enhanced, or refined with respect to specific instances of patient-handling. For example, a trainee might first be required to formulate an intended plan of action to handle a small, frail, stroke patient moving from a bed to a chair. She might subsequently be asked to formulate action plans for a further series of...
situations, for example, carrying out the same task with an obese, uncooperative, catheterised patient.

6.3.1 Rationale for intervention

As previously stated, the programme aims to produce in the trainee a set of behaviours compatible with reducing the risk of LBP or injury. The first step in rationalising a means of enhancing the training programme, is consideration of the constraints imposed by the programme's overall goals.

These constraints can be considered in relation to the notions of costs previously expressed (see section 4.5.1). According to Dowell and Long (1989) structural costs are those concerned with, for example, the length of the training programme, whereas behavioural costs are those borne by the trainee.

In relation to structural costs, if the length of a training programme was not constrained financially, then extending its length by, for example, adding extra physical practice might be a selected way of enhancing the programme. However, given the resource limitations imposed on healthcare in the mid 1990's such enhancements would incur impractical structural costs. In relation to behavioural costs, it is necessary to consider the impact of any enhancement on the trainee. Although training programmes aim to minimise work-related LBP, their recipients are likely to be mixed in terms of their history of the complaint of LBP. Clearly, for some individuals with a history of LBP the addition of
physical practice may be undesirable and impractical. Certainly an effective training programme must accommodate lifters with different characteristics. Thus, on pragmatic grounds, it appears that the selection of an enhancement such as cognitive training may be indicated. The next section considers the implications of physical and cognitive training.

6.3.2 Interventions and the model - Selection of cognitive training

6.3.2.1 Physical practice

Regarding the model, an increase in the amount of physical practice would support an enhanced quality of low level representations, but not necessarily their translation into the generalisable high level knowledge needed to support transfer. At best, increased physical practice is likely to support the elicitation of an automatic low level motor response. By supporting the quality of the low level representations without supporting their translation, planning and control is likely to be unaffected or even undermined rather than enhanced, because certain well-rehearsed, low level behavioural representations may be more likely to be selected by particular goal structures. In terms of the model, physical practice would appear to directly support the executing and controlling processes rather than the planning process.

6.3.2.2 Cognitive training (practice)

Cognitive training is defined, for the purposes of this project, as the use of non-physical

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1 Practice is defined as the repetitive use of mental or physical means to establish or develop a stored knowledge representation of a particular sort, for example, of some kind of action mental or physical.
Chapter 6: Developing a solution

means to provide support to subjects' plans. A plan is the intentional representation of the specification of either the required domain states or of the intended behaviours.

The form of cognitive training selected for further investigation is mental imagery. The use of mental imagery requires novices to imagine themselves in specific patient-handling situations. This allows novices to retrieve their default plans from memory and to evaluate them in different contexts. By combining visual and verbal inputs with the formation of plans in the imagined situations, mental imagery also has the potential to enhance the representation of knowledge-of-tasks. This could occur in two ways. Firstly, by selectively enhancing the representation of particular objects, and thus indirectly enhancing plans. Secondly, by offering direct enhancement to plans.

Mental imagery is predicted to support planning and control, by providing a means by which novices can retrieve their default plans and, 'run through' the likely outcome of applying the default, thus providing a basis from which the default can be evaluated and refined for the particular situation.

6.3.3 Summary

To summarise, the model predicts that the addition of cognitive training will support planning behaviours. This will lead to the formulation of a goal structure appropriate to a non-taught situation and recruitment of appropriate behaviours to satisfy this goal structure. Conversely, the model suggests that the addition of physical practice will
support the control and implementation aspects of performance, but predicts that it will have no effect on planning. As the control and implementation aspects are not those previously identified as deficient, no improvement of performance is predicted and performance may degrade.

### 6.4 Developing the specific prescription

This section briefly reviews that background information concerning mental training which is relevant to prescribing the enhanced training programme.

#### 6.4.1 Background and definitions

The widespread belief that motor learning is controlled at a cognitive level is reflected in the argument advanced by Shea and Zimny (1988) who suggested that motor learning is largely influenced by people's goals, the knowledge they possess and the incorporation of their new knowledge with old. Shea and Zimny believe this knowledge is combined in a mental representation of the motor task and is acted on by strategic and heuristic processes.

Evidence from a variety of experiments has convincingly demonstrated that rehearsing a skill in imagination without overt action, can result in improvements in both learning (Hall and Goss, 1985) and performance (for reviews, see Feltz and Landers, 1983; Murphy, 1990). However, this may not always be the case (Smyth, 1975; Epstein, 1980). Although
it is difficult to characterise when imaginary rehearsal will be effective and when it will not, several authors have attributed the different effects to lack of control over inter-individual variables (Denis, 1985), and Murphy (1990) complains that the appearance of a variety of paradigms under the term 'mental practice' precludes the formulation of any general conclusions.

This type of rehearsal has variously been referred to as cognitive training, mental practice, covert practice, imagery practice, implicit practice, imaginary exercise, mental rehearsal, motor imagery, mental review, and symbolic practice. Increasingly, the shift in focus has been away from the concept of mental practice to that of mental imagery raising the question of if and how they differ. Singer (1980) suggests that they are the same concept, i.e. they both refer to, 'task rehearsal in which there are no observable movements'.

However, this definition could embrace an individual's thinking about a skill or watching someone else perform it. The current trend is to either consider mental imagery as a component of mental practice (Hall, Buckholz, and Fishburne, 1992) or else to view the two terms synonymously. The latter view is reflected in the definition of mental practice (MP) offered by Decety (1993):

>'an imagined rehearsal of a motor act with the specific intent of learning and improving it without any simultaneous sensory input nor any overt output'

Given that motor acts are commonly conceived as single behaviours, applying this
definition to the specific research problem leads to the following definition of mental practice:

'an imagined rehearsal of a set of behaviours required to perform a task with the specific intent of learning and improving them without any simultaneous sensory input nor any overt output'

This operational definition will be used in the following discussion. Within this definition, the imagined rehearsal can be presumed to provide the means of accessing a stored knowledge representation which is then operationalised mentally. In sections 6.4.2 - 6.4.7, discussion of the effects of mental practice, will be followed by consideration of the influence of task type, level of expertise. An attempted integration of the background material appears in section 6.4.8.

6.4.2 Presumed effects of mental practice

The effect obtained by mental practice (MP) is usually compared with the effect obtained by a similar period of time spent physically practising, and with the effect on a control group. The results broadly fall into one of two categories. Either, the MP group produces significantly higher scores than the control group, but lower scores than the physical practice (PP) group, (Twining, 1949; Mendoza and Wichman, 1978) or, both the MP and PP group produce significantly higher scores than the control group but they do not differ significantly from each other (Vandell, Davis and Clugston, 1943; Wrisberg and Ragsdale, 1979; Kohl and Roenker, 1983).
Important additional findings come from research in which a combination of physical and mental imagery practice has been examined (for a review, see Fishburne and Hall, 1987). The overall conclusion appears to be that an appropriate combination of PP and MP can be as valuable as a larger programme of PP alone.

The improvement effected by MP cannot be attributed to any external consequences or to the effect of repeated stimulation, so change can only take place through the medium of some internal representation of the skill. A number of theories advanced to account for mental practice effects were compared by means of a meta-analysis of 60 studies by Feltz and Landers (1983). A classic theory is that mental practice evokes activity in the motor output system and, although this is largely suppressed, it is detectable in EMG records. According to the theory, this activity is enough to generate minimal kinaesthetic feedback through which some learning is mediated (Jacobson, 1932). A more plausible theory supported by the meta-analysis, is that mental practice permits the rehearsal of cognitive processes associated with task performance. In other words, it affords a subject the opportunity to generate and mentally 'try out' certain hypotheses regarding the best course of action to take under a given set of conditions, with subsequent enhancement of performance. Alternatively, Paivio (1985), noting the widespread use of imagery in sport suggests that its motivational role in the athlete may have been underestimated.

The specifically cognitive nature of mental rehearsal in one kind of motor task was demonstrated by Johnson (1982). He used a linear positioning task to demonstrate the
well-established phenomenon of interference in short term motor memory. In between making a linear movement of a particular length and recalling it, subjects were required to make a movement twice as long. This led to the recalled movement being overestimated. Johnson then showed that instructions to imagine making a movement twice as long produced the same bias in recall as an interpolated movement.

When subjects were required to tap on the table with the hand they were simultaneously imagining moving laterally, they retained the imagery induced bias. This led to the conclusion that the effect of imaginary movement was isolated from any muscular activity. Furthermore, Johnson's (1982) study demonstrated that imagery is successful only if the image formed is accurate. Thus the recall of an 'incorrect' image, that is an image whose referents are different from the original movement, can systematically have biasing effects on performance.

More recently, Hall, Bernoties and Schmidt (1995) replicated Johnson's (1982) findings in another context, that of a simple 'knockdown' motor task, leading to the general conclusion that, at some level of representation, overt and imagined actions appear to be functionally equivalent.

However, clear data showing the benefits of MP are difficult to obtain, partly because of methodological difficulties inherent in any investigation of mental practice, and partly because the wide variety of study designs makes comparison of results difficult.
Methodological problems include difficulty in ensuring that subjects do not practice outside the training period, difficulty in controlling for subjects' imagery ability and difficulty in determining subjects' compliance with imagery instructions. For reviews of these difficulties see Grouios (1992) and Moran (1993).

6.4.3 Effects of mental practice on different tasks

The effect of MP on a variety of skills, simple and complex has been investigated. Examples include card sorting (Perry, 1939), ring tossing (Twining, 1949), pursuit tracking (Rawlings and Rawlings, 1974) and weightlifting (Shelton and Mahoney, 1978). Feltz and Landers (1983) used a 'meta-analysis' technique to analyse the statistical trends in 60 studies of mental practice. They compared the 'effect sizes' for mental practice on cognitive, motor, and strength tasks. They reported a significantly larger effect size for cognitive tasks, such as finger maze learning, than for tasks such as dart throwing, and only a small effect size for strength tasks. As Paivio (1985) explains, accepting the view that MP facilitates performance only to the extent that cognitive factors are inherent in the activity indicates a need for a detailed analysis of the task prior to the prescription of MP.

Additionally, the sporting literature is replete with examples of activities in which mental practice has been shown to have a positive effect on performance. For example, benefits have been demonstrated in backstroke swimming (Yamamoto and Inomata, 1982) and swimming starts (White, Ashton, and Lewis, 1979) to name but two. However, despite this abundant interest, few definitive conclusions have been reached concerning which
skills are most likely to benefit from mental training.

As early as 1964 Richardson posed the question:

'Has mental practice any relevance to physiotherapy?'

yet there has been curiously little work concerning the use of MP in the clinical setting. However, this situation has begun to change as health personnel have begun to realise the potential benefits of including mental practice in both rehabilitative programmes (Warner and McNeill, 1988; Yue and Cole 1992) and in medical education (Rakestraw, Irby, and Vontver, 1983).

To summarise, much of the work concerning MP has relied either on the use of laboratory tasks or else on its application to sporting tasks. In spite of a limited but increasing amount of work in the rehabilitation setting there still appears to be little work relevant either to everyday tasks or to those which form part of patient-handling.

### 6.4.4 Effects of mental practice on transfer

As discussed in section 4.4.3 several authors (Bransford, Franks, Morris, and Stein, 1979; Lee, 1988) have suggested that it is the similarity of the underlying cognitive processes that will determine the effectiveness of practice in promoting transfer of training. Mental practice provides a potential means of enhancing the cognitive specificity of training and so facilitating transfer. Traditionally much research on MP has concentrated on its role in the learning of skills (e.g. Minas, 1978; Ryan and Simons, 1981). Only in the last 10 years
or so has the effect on transfer of learning to performance expanded (Woolfolk, Parrish, and Murphy 1985; Murphy, Woolfolk, and Budney, 1988; van Gyn, Wenger and Gaul, 1990).

6.4.5 Effects of mental practice on novices and experts

Studies concerning the effects of mental training on novices and experts are equally inconclusive. Thus, Clark (1960) found that PP and MP were equally effective in basketball free-throw shooting with varsity and junior varsity high school players. Subsequently, Corbin (1967a; 1967b) investigated this problem using a wand juggling task. His findings suggested that MP can only be effective if subjects have experience with the task, and if PP precedes their exposure to MP. More recently, Blair (1989) found a significant improvement in soccer skills in both novices and experts.

A long held view is that MP is effective mainly in the early stages of skill acquisition. This accords with theoretical assumptions that the early phases of skill learning are essentially cognitive in nature (Fitts and Posner, 1967; Adams, 1971). Conversely, if MP is introduced too late in the learning procedure it should have less effect since the internal representation is well formed (Zecker, 1982). In fact, MP effects have been found at all stages of learning (Feltz and Landers, 1983), making it reasonable to presume that there is potential for MP to affect novices' patient-handling abilities. What is uncertain is precisely how to configure any enhancement to the training programme.
6.4.6 Mental imagery instructions

One particular problem in designing an enhanced training programme is that few studies report the content of imagery instructions (Caudill and Weinberg, 1983; Wilkes and Summers, 1984). Furthermore, there is little empirical basis for the design of instructions other than that subjects find it easier to create images of concrete objects as opposed to abstract ones (Gorman, 1961; Paivio, 1969) where concreteness is defined in terms of the ease with which a stimulus provokes an image of an object (Paivio, 1969). Denis (1985) comments that Johnson's (1982) findings indicate that the design of mental imagery instructions should be detailed and as accurate as possible, whilst Qualls (1982) cautions that instructions which are too explicit may excessively 'direct' the image and impair its quality.

Imagery instructions may be either visual where the emphasis is on subjects creating an image, or kinaesthetic where the emphasis is on subjects creating the feeling of a movement. Although few studies have compared the effects of visual and kinaesthetic instructions, there is some evidence to indicate that the inclusion of kinaesthetic imagery is important (Ryan and Simons 1982).

A further aspect to consider in the design of imagery instructions is the imagery perspective subjects are instructed to assume. An external imagery perspective requires subjects to view themselves from a third person perspective, whereas an internal perspective requires subjects to image their performance from within the body (Mahoney
and Avenor, 1977). Research comparing the two perspectives, in the main, indicates superiority of the internal perspective (Rotella, Gansneder, Ojala and Billing, 1980), although as Annett (1995) points out the optimal perspective may be highly task dependent.

Although there is little work concerning the optimal way of delivering imagery, Surburg (1968) investigated varieties of delivery in the context of a tennis stroke. Subjects who underwent audio-instruction appeared to develop more controllable images and evidenced better performance than those who underwent visual or audiovisual presentations. The suggestion was that when instructions were presented visually subjects were discouraged from forming their own images.

6.4.7 Duration and frequency of mental practice

Studies concerning the relative scheduling and length of MP sessions have produced conflicting results. Ryan and Simons (1982) found that more frequent MP resulted in decreased performance after a certain point, and Schmidt (1975) established that MP benefits performance as a decreasing function of the amount of practice. Nonetheless, optimal amounts of practice have not been established and neither has the optimal length of a practice session. Equally uncertain is the relationship of the time which elapses between MP sessions and assessment of performance.

The length of MP sessions has varied from ten seconds (Smith and Harrison, 1962) to
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thirty minutes (Vandell et al., 1943) and in 1972, Corbin suggested that the optimal time for undertaking imagery based CT was five minutes. Similarly, Twining (1949), on the basis of subjective reports, reported that concentration for MP was no longer than five minutes, although this is not well established. For example, Weinberg, Gould and Jackson (1981) investigated the effects of four time periods on strength performance assessed immediately following practice. The periods used were a) 15 seconds b) 30 seconds c) a time selected by the subject and d) a condition in which subjects were matched to subjects in the self-selected condition in c). No significant differences were found between the groups. Similar results were obtained in a subsequent study using 60 second intervals (Caudill and Weinberg, 1983). However, in contrast, Feltz and Landers (1983) reported that the greatest effects for strength tasks, as compared to motor or cognitive tasks, were found after much longer intervals of 7-8 minutes or ten trials of MP. Stick (1970) in a study on volleyball skills established that the effects of three minutes of MP per day spread over a few weeks were superior to those of one minute per day. Furthermore, Feltz and Landers (1983) found a trend supporting the view that the effects of MP tend to be greater when the post-test is administered later rather than immediately after the mental practice.

6.4.8 Summary

There appears to have been little empirical investigation of the effects of MP on transfer performance, most studies having confined themselves to a pre and post-test design using the same task in each assessment. However, substantial empirical evidence suggests that the use of MP may support the more effective training of patient-handling skills. Thus
both the model and the existing experimental evidence indicate that appropriately
prescribed MP could support the development of an enhanced patient-handling training
programme. In terms of optimising the specification of the prescription, a general problem
exists in terms of the dearth of research concerning non-sporting real world tasks. In turn
there is a lack of any consensus regarding the optimal length, temporal distribution and
mode of delivery of cognitive training. Hence, the next section describes the specification
of the enhanced training programme.

6.5 Configuring the enhanced training programme

To recap, the existing training programme fails to support novices' performances of
patient-handling in non-taught situations. The requirement is for specification of an
enhanced training programme which will subsequently be evaluated. This section describes
how the published work together with a small series of optimisation studies was used in
order to specify the enhanced programme.

6.5.1 Length and temporal organisation of CT sessions

Regarding the optimal temporal organisation of cognitive training sessions, there is some
indication that, as with physical practice, distributed mental practice schedules are
preferable to the massed organisation of practice (Corbin, 1972; Gabrielle, Hall, and Lee,
1989). However, the preferred temporal organisation is unclear. Hence, on practical
grounds, the temporal distribution selected was three 20 minute sessions of cognitive
training at weekly intervals.

### 6.5.2 Mode of Delivery of CT instructions

Instructions regarding mental imagery may be delivered by subjects either reading a set of instructions (e.g. Epstein, 1980) or by listening to them (e.g. Harris and Robinson, 1986). Subjects' reading speeds may vary, so in order to try to standardise the delivery of the additional training, the enhanced training programme required subjects to listen to tape recorded instructions. The instructions asked each subject to imagine themselves performing two patient-handling tasks. In terms of considering the speed of delivery of the instructions, it was necessary to decide whether subjects should have control over the speed of delivery of instructions, for example, should they be required to listen to a specified number of instructions or whether they should receive continual instructions for a set period of time.

These options were investigated informally by asking two individuals to listen to instructions delivered firstly, via a central tape recorder and secondly, via individual, personal tape recorders which they could switch on and off as they chose. The preference was for centrally delivered instructions which were reported to be less distracting than those delivered individually.

### 6.5.3 Content

The main guidance to the content of imagery instructions provided by the literature is that
subjects find it easier to create images of concrete objects as opposed to abstract ones (Gorman, 1961; Paivio, 1969). For this reason, imagery instructions which focused on the physical attributes of the domain objects, e.g. a patient's size, the nature of physical attachments such as drips, were tested. Abstract attributes, e.g. a patient's levels of pain or cooperation were omitted. Several workers (Epstein, 1980; Suinn, 1983) have argued that the perspective of the images may influence the outcome of the physical activity. They state that internal imagery (feeling oneself do) as opposed to external imagery watching oneself do is superior in the enhancement of physical performance.

Informally, two individuals were asked to describe what they were thinking as they tried to imagine themselves handling a patient in a clinical setting. This formed the basis for the content of the CT instructions.

The criteria for the selection of the tasks to be imagined in the experimental groups were derived from the findings of Study 1 to include:

a) tasks which were ecologically valid

b) tasks which required a variety of configurations of behaviours concerned with patient-handling

The tasks were:

Scenario 1: Shoulder lift (slide) in a patient with an intravenous drip in situ

Scenario 2: Assisted bed - stand manoeuvre in a patient who has undergone a Total Hip Replacement; has wound drains in situ
6.5.4 Components of enhanced training programme

From the findings of the informal studies, the following enhancement protocol was derived:

** Three sessions of CT, at weekly intervals
** Three repetitions of instructions within each five minute imagery period
** Each session was 20 minutes in length. This was divided into four, 5 minute sections and thus comprised 5 minutes 'imagining' scenario 1, followed by 5 minutes 'imagining' scenario 2. This scheme was then repeated giving a total of 6 trials of each scenario.
** Instructions were delivered by pre-recorded tape, from a central source
** Subjects were instructed in two handling scenarios as above.

6.6 Summary

Having identified an enhancement to the training programme, there is a requirement for an empirical study to investigate the effectiveness of the enhanced programme in terms of providing support to planning and control and in turn supporting transfer.
Chapter 7

STUDY 2: INVESTIGATION OF THE EFFECT OF ALTERNATIVE FORMS OF INSTRUCTION REGIME ON TRAINING OF PATIENT-HANDLING

7.1 Chapter overview

Chapter 7 describes the investigation of two alternative solutions to the research problem exposed in Chapters 2 and 3. The development of the solutions was described in Chapter 6. The results show that the problem can be reduced and the findings provide information for development of the cognitive model of patient-handling activities.

7.2 Background

The study described in Chapter 3 demonstrated the existence of a problem for novice physiotherapists. Study 1 found that novices failed to transfer behaviours learnt in the classroom situation to the workplace. The study identified differences between the knowledge acquired by the novices and that intended by the training programme. There were also differences between the knowledge acquired by the novices and that evidenced by the experts, whose knowledge was closer to that intended by the training programme. One of the main reasons why novices found it difficult to transfer their skills to the workplace related to their deficient planning. This was exemplified by the difficulty novices experienced in thinking in advance about what to do, and in responding to
unexpected events.

This chapter describes an empirical study which attempts to address the ineffectiveness in training by testing the effects of enhancements to the training programme suggested by the model.

7.3 Rationale for study

As identified in Chapter 6, the proposed solution takes the form of an enhanced training programme. The programme attempts to provide novices with knowledge which enables them to more effectively transfer knowledge acquired in the classroom, to their performance of novel patient-handling tasks in the simulated workplace.

To recap, the model predicts that the addition of cognitive training to the training programme, will provide increased support to novices' planning and control behaviours. This should result in both the formulation of a goal structure which is more appropriate to a non-taught situation, and in the recruitment of appropriate behaviours to satisfy this goal structure.

An empirical study was required to test the effectiveness of the specific solution in terms of its effect upon the transfer problem, and to allow comparison between the chosen solution and an alternative, i.e. additional physical practice. To achieve this, a study was
required which would allow adequate control of experimental conditions such that the effect on transfer of two solutions could be distinguished. The two solutions were cognitive training and additional physical practice.

Consideration of the effect of the solutions on transfer required assessment of performance and of any associated planning behaviours. Assessment of the transfer phenomena necessitated that, in order to eliminate any specific learning effect, the tasks which formed the basis of the assessments of subjects' pre and post-intervention performances were different. As the problem identified in Study 1 was one of inefficient transfer to the workplace, a further requirement of this study was to ensure equivalence between its context and that of Study 1. Therefore, effectiveness needed to be considered with respect to a workplace setting. To simultaneously satisfy both the latter need and the need to test transfer using adequately controlled experimental conditions, the pre and post-intervention assessments were performed using task simulations.

7.4 Development of methodology: informal work

7.4.1 Aim of study

The aim of the study was:

to investigate whether novices who are supplied with knowledge missing from the training programme, via relevant cognitive training (CT\textsubscript{ad}), achieve better transfer of knowledge to support their behaviours in non-taught patient handling
Chapter 7: Study 2

situations than novices who receive alternative additional knowledge.

The missing knowledge is that which is postulated to support the planning and control behaviours of the novice. Informal studies were performed in order to identify a protocol for additional physical practice, and to identify suitable ways of assessing planning behaviours.

7.4.2 Equivalence of physical practice control group

Additional physical practice (PP) was selected to provide the comparative solution to additional CT for two reasons. First, because, from the predictions provided by the model, additional PP was not predicted to have any direct effect on planning so it provided the most direct comparison of an alternative solution. Second, although the addition of substantial physical practice to patient-handling programmes has intuitive appeal, in pragmatic terms it is likely to be too financially expensive to be a useful solution to the problem. For example, substantial costs are associated with the provision of people to supervise and ensure the safety of any additional physical training. These may be coupled with costs in terms of trainees time and the need to provide adequate space in which to carry out the training.

In configuring the additional physical practice, the principal concern was to provide an alternative solution configured in a way which was directly comparable with the cognitive training. However, whereas the relevant CT was designed to be, within certain constraints,
optimal, to test the effectiveness of the CT, the requirement was for the alternative solution to be configured in a comparable way. Achieving comparability may have precluded optimisation of the physical practice. Nonetheless, in general terms a main factor influencing the organisation of physical practice concerns the advantages of distributed over massed practice (e.g. Shea and Morgan, 1979). This advantage was accommodated, so it seemed reasonable to suggest that the effect of any lack of optimisation was minimal.

When subjects engage in mental rehearsal of a loaded movement, it is slower than the real time physical rehearsal (Decety, 1993), so there was a requirement to assess on what basis equivalence of the control and experimental group could be claimed. Ultimately, this remained a matter of judgment. However, the issue of equivalence can be viewed in two ways. Firstly in terms of teaching effort, i.e. the number of repetitions of instructions or their temporal length, and secondly, in terms of teaching effect, i.e. the optimal configuration of physical or mental practice.

Equivalence based on teaching effect was not sought because, within the overall remit of the research problem, the need is for a cost-effective intervention. In other words, the requirement was to support correct patient-handling with a minimum training time. Each supervised physical training session has, at minimum, potential costs with respect to trainers and trainees' time. Following this argument, the amount of physical training which could be added to the training programme is pragmatically constrained. Therefore the
amount acting as a control needed to be representative with respect to the kind of intervention that it might be reasonable to make. It could be argued that substantial, (theoretically, even unlimited) additional physical practice might have been an effective enhancement to the training programme. However, enhancement of the programme per se, is a distinctly different issue from the research problem being addressed here, i.e. enhancement of the training programme within the confines of improving the overall effectiveness of training. Hence, a pilot study was required to reconcile the perspectives of providing adequate control conditions with the ultimate requirement for efficient training.

Informal assessment was made of whether the PP enhancement should be matched to the CT enhancement with respect to teaching time or with respect to the number of repetitions of instructions. Three subjects underwent physical practice for the same period as the experimental group, i.e. 20 minutes. They were required to physically practice the two patient-handling tasks described in the CT intervention and were encouraged to rest intermittently as required. The number of repetitions of each task was recorded. The design of the relevant cognitive training required subjects to perform six repetitions of each task making 12 repetitions in total, across the 20 minute training session. Hence, the group undergoing physical practice were encouraged to perform as close to 12 repetitions as possible.

The results of this informal work showed a range in the number of lifts performed of 9-12.
Two factors emerged. First, subjects tended to perform more of one lift than the other and second some subjects tended to rest because of boredom rather than fatigue. These findings were incorporated into the physical practice intervention by giving subjects instructions to try to perform six repeats of each task, only stopping when fatigued. Constraining subjects' performances to within the limits of fatigue was necessary to protect them from any adverse health or safety consequences.

7.4.3 Additional physical practice enhancement

From the literature and the informal work the following enhancement protocol was derived:

** Three sessions of additional PP at weekly intervals

** Each session was 20 minutes in length, comprising up to six repetitions of two patient-handling tasks

** Subjects were given written instructions in the same two handling scenarios used in the CT_{CT} training sessions.

7.4.4 Assessment of planning behaviours

Planning behaviours are not always easily exposed or identified. In such circumstances their assessment relies on the use of several convergent methods. For example, observed sequences of behaviour may be combined with direct questioning of subjects and with subjects' own descriptions of their behaviours. The latter may be obtained via retrospective or concurrent verbal protocols (Ericsson and Simon, 1984). The likely level
of interference with the performance of a motor task is a marked disadvantage if verbal protocols are obtained concurrently with a subject's performance of a task. Equally, retrospective protocols may lead to subjects providing post-hoc rationalisations of their actions rather than reporting the behaviours that actually occurred, and analysis of the protocols relies on inferences made by the analyst. A further problem is that as subjects become more skilled they may be less able to describe their behaviour verbally or may be unable to account for the increasingly subtle features of skilled performance (Ericsson and Simon, 1984). To address these problems Ericsson and Simon (1984) propose the use of videorecordings to prompt subjects as retrospective protocols are obtained. In relation to the requirements of Study 2, reliance on retrospective verbal data was unlikely to capture some aspects of behaviour. Hence, it was necessary to combine retrospective verbal protocols with videorecordings of the overt behaviours that occurred and with questioning of the subjects. Informal work aimed to identify:

(i) a way of enhancing the exposure of planning behaviours

(ii) a way of analysing the protocols

7.4.4.1 Exposure of planning behaviours - planning probes

To facilitate the exposure of planning behaviours, the post-intervention simulation was designed to include two planning probes. A planning probe was defined as:

'An unexpected event which interrupts a subject's behaviour, which may change the intended goal state, and which forces a response, planned or unplanned from
Two types of planning probe were conceived. First, an internal probe, e.g. an event internal to the task that someone with a good plan might not have specifically expected, but could have foreseen as likely. An example of an internal probe might be a patient complaining of undue pain. Second, an external probe, e.g. an event that is unlikely to have been considered in advance and which will force a novice to reconsider her plan. An example of an external probe might be a patient in an adjacent bed having a cardiac arrest.

By assessing a subject's immediate response to each probe insights were obtained into the nature of a subject's planning. Use of the probes was aimed at improving the sensitivity of plan assessment by enabling distinction of subjects with a plan from subjects without, and also subjects in whom a plan exists but is inadequate.

The use of a variety of planning probes (an emergency telephone call, a simulated cry for help from a person in the same room, a simulated faint of a patient being handled, simulated severe pain of a patient being moved) was assessed informally to identify probes that were repeatable and therefore usable in an experimental context. It was also necessary to assess the extent to which such probes achieved their intended goal of exposing planning behaviours. The external probe selected was an emergency telephone call, as subjects tended to expect the experimenter to respond to a simulated cry for help from a person in the same room. The internal probe selected was the simulated faint because of the difficulty in reliably and repeatedly simulating severe pain.
7.4.4.2 Identifying planning behaviours from retrospective protocols

Two novice subjects were interviewed and asked to describe their behaviours when carrying out a patient-handling task, in order to crudely identify the types of utterances which might be assumed to be indicative of planning behaviours. Three principal categories of plan were identified: plan formulation, plan update and plan failure (see Appendix 3 for details of examples).

1. Plan formulation:
These were utterances concerned with intended behaviours, e.g. 'I intended to', 'I was going to'.

2. Plan updating:
These were utterances concerned with changing the intended behaviours, e.g. 'I realised that'.

3. Plan failure:
These were utterances concerned with failure of a particular behaviour, indicating either an inappropriately selected behaviour (and thus by definition plan), or else an incorrectly defined goal (and thus by definition plan). Within this category fall utterances which may indicate the existence of a poor plan, e.g. 'I found that I couldn't'. Failure to plan was also assumed to be indicated by a relative absence of comments in categories 1. and 2.
The pilot work also enabled the development of five short questions designed to facilitate access to subjects' planning behaviours. In conclusion, the assessment of planning behaviours relied on the combination of data drawn from verbal protocols, videorecordings, and subjects' responses to planning probes and to questioning.

7.5 STUDY 2

7.5.1 Experimental Design

The use of a within subjects design was rejected because of the substantial likely carryover effects predicted from the CT and possible from the other interventions. A matched, controlled, between subjects experimental design was used. To test the hypotheses, three independent experimental groups were required. Subjects in each group underwent a baseline assessment and a post-intervention assessment.

The independent variable was relevant cognitive training ($\text{CT}_{\text{rel}}$). Three experimental groups were defined with respect to this variable, including a control group which underwent additional physical practice (PP) only, and a control group which underwent irrelevant cognitive training ($\text{CT}_{\text{irrel}}$), i.e. training not directly concerned with a subject's performance of a task.

The dependent variables were:

a) performance scores (in respect of performance of patient-handling on a 'model'
7.5.2 Hypotheses

Two experimental hypotheses were formulated:

1. The addition of relevant cognitive training ($CT_{rel}$) to the training programme will enhance actual performance and hence bring it closer to desired performance. The addition of physical practice to the training programme will mainly support implementation behaviours, and to a lesser extent, control behaviours. Thus, the addition of PP will not enhance actual performance to the same extent as $CT_{rel}$ and may diminish performance.

   $H_1$ The performance scores, i.e. scores obtained from the patient handling performance checklist of subjects who have undergone $CT_{rel}$ will be better than the scores of subjects who have undergone irrelevant cognitive training ($CT_{irrel}$) or additional physical practice.

   $H_0$ There will be no differences between the performance scores, i.e. scores obtained from the patient-handling performance checklist, of subjects who have undergone $CT_{rel}$ compared to those who have undergone $CT_{irrel}$ or additional physical practice.
2. The addition of $CT_{rel}$ to the training programme will support novices' planning behaviours.

$H_1$  There will be a difference between the comparative number and type of planning behaviours of subjects who have undergone $CT_{rel}$ compared to those who have undergone $CT_{irrel}$ or additional physical practice.

$H_0$  There will be no differences between the comparative number and type of planning behaviours of subjects who have undergone $CT_{rel}$ compared to those who have undergone $CT_{irrel}$ or additional physical practice.

### 7.5.3 Subjects

Three groups of subjects were recruited from the population of undergraduate physiotherapy students at King's College, University of London, via personal approach. Each experimental group had six subjects. All subjects were female, English speaking and with no previous formal experience of CT via mental imagery. None of the subjects were obese or had any physical disability which might have affected their ability to manually handle. None of them reported experience of low back pain which had interfered with their daily activities in the previous 12 months.
Subjects were matched, on the basis of their performance scores in a simulated workplace task, into groups of three. Subsequently, each subject within a trio was randomly allocated to one of three experimental groups. The simulated workplace task (S1) used for matching was that used in the pre-intervention assessments. Arguably, subjects should have been matched in terms of planning behaviours as well. However, on the basis that better planning may be related to better performance, this seemed unnecessary. Furthermore, consideration of the amount of variability in performance when assessed under reasonably controlled conditions, as evidenced by subjects' classroom performance scores in Study 1, (standard error = 0.41, coefficient of variation = 11.55%) suggested that electing to match subjects in one respect only was reasonable.

Subjects in all of the groups had undergone training and had had the opportunity to practice large numbers of the manoeuvres, thus any practice effect offered by the interventions was presumed to be negligible. Subjects underwent additional training thus:

1. **Group A:** Relevant cognitive training (CT\textsubscript{rel}) implemented via mental imagery. The CT\textsubscript{rel} involved subjects receiving instructions to imagine themselves performing two patient-handling tasks: a) moving a patient along the bed and b) helping a patient get out of bed.

2. **Group B:** Additional physical practice (PP) of the same patient-handling tasks as in 1a) and b). Subjects were not given clinical details to discourage them from forming images.
3. **Group C**: Irrelevant cognitive training (CT_{irr}) implemented by instructing subjects to create images of the clinical presentations only of patients similar to those 'moved' by subjects in Groups A and B. To try to ensure that there was no effect on motor learning, the instructions did not involve the subjects imagining themselves performing any motor task.

Full details of the training instructions appear in Appendix 3.

7.5.4 **Dependent variables**

Two dependent variables were assessed:

1. Performance scores, i.e. obtained from checklist of performance criteria used in Study 1. Performance was assessed by two independent raters. The first rater repeated the assessment at least one week after the first assessment enabling intra-rater reliability of the first rater to be assessed. Inter-rater reliability was assessed by comparison of the first rater's judgements with judgements made by a second rater.

2. Behavioural assessment, i.e. assessment of planning behaviours.

   Planning behaviours were assessed via:

   a) retrospective protocols (supported by videorecordings)

   b) short questionnaire (see Appendix 3): the questions directly concerned subjects' planning behaviours. Their purpose, in terms of the model, was to
indicate the existence of a goal stack, partial goal stack, or no goal stack.

c) responses to surprise interventions, i.e. the internal and external planning probes.

7.5.5 Materials - Simulations

The criteria for the selection of the tasks to be used in the pre and post-intervention simulations were derived from the findings of Study 1 and were as follows:

a) tasks which were commonly performed

b) tasks in which compliance with taught procedures was poor

c) tasks which could be simulated with reasonable fidelity

The pre-intervention simulation (S1) required subjects to use a 'waist' hold to assist a 'model' patient, with a drip and catheter attached, moving from sitting in a low chair, to standing. The fidelity of the simulation was assessed and improved by comparison with observations made in the workplace and the video data obtained in the first study.

The post-intervention simulation (S2) was intended to be as distinct as possible from the pre-intervention simulation, in order, to minimise any learning or practice effect. Otherwise, this task was selected according to the same criteria. Subjects were required to assist a 'model' patient lying supine, with a wound drain, transferring from a bed to a chair.

The two planning probes were as follows:

1. Internal - model assumed a faint. This was timed to occur just as the model was
helped to move from lying in the bed into sitting in the bed.

2. *External* - the subject was informed of an urgent telephone call requiring her to respond immediately. This was timed to occur as the subject began to help the model patient lower herself into the chair.

The response to the probe with respect to the patient-handling task was assessed by two independent raters using a four-point scale defined in Appendix 3. Details of the simulations appear in Appendix 3.

**7.5.6 Procedure**

Eighteen subjects were asked to perform one patient-handling task under simulated conditions to enable pre-intervention assessment of performance and, implicitly, of associated behaviours. The pre-intervention assessment took place 1-7 days before the start of training. The general purpose of the experiment was explained to the subjects but they were blind to its specific purposes. Subjects were asked to sign a consent form and were asked not to discuss the experiment with anyone else.

Subjects were videorecorded as they carried out the patient-handling tasks. The experimenter answered any questions prior to the start of the assessment and, as far as possible, restricted conversation during the assessment. Subjects underwent additional training according to their allocated group. One to seven days following completion of the training, subjects were videorecorded again in a simulated environment as they carried out
a patient-handling task (S2). The post-intervention simulated task incorporated two planning probes. Following the post-intervention simulation, subjects were asked to verbalise all of their thoughts while watching themselves on video, to enable acquisition of as full a description as possible of their behaviours during their performance. They were also asked five short questions.

Subjects' compliance with mental imagery instructions cannot be measured directly and is a potential source of error. Equally subjects differ in their ability to create images. To try to assess both of these sources of error, following the training, subjects in Groups A and B were given a standard questionnaire (Hall and Pongrac, 1983, Appendix 3). To assess subjects' compliance with the instructions the number of practice lifts performed by each subject was noted by an observer.
### 7.5.7 Summarised experimental schedule

<table>
<thead>
<tr>
<th>Experimental procedure</th>
<th>Pre-intervention S1</th>
<th>Intervention</th>
<th>Post-intervention S2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental procedure</strong></td>
<td>Measurement of performance on simulated task 1</td>
<td>Subjects exposed to:</td>
<td>Measurement of performance on simulated task 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Group A - $\text{CT}_{\text{rel}}$ - using two task scenarios or</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Group B - Physical practice - using two tasks or</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Group C - $\text{CT}_{\text{irrel}}$ - using two scenarios</td>
<td></td>
</tr>
<tr>
<td><strong>Data collected</strong></td>
<td>Performance -</td>
<td>Compliance -</td>
<td>Performance -</td>
</tr>
<tr>
<td></td>
<td>judgements made by independent raters using checklist (to support test of $H_1$)</td>
<td>Groups A and C: imagery questionnaire (to check/test subjects ability to create images and their compliance with CT)</td>
<td>independent raters using checklist</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Behaviours</strong> - identified from a) videos b) retrospective protocols c) probes d) questionnaire (to support tests of $H_1$ and $H_2$)</td>
<td></td>
</tr>
</tbody>
</table>
7.6 Data analysis

7.6.1 Analysis of Performance Data

Each subject achieved an overall performance score out of a maximum score of 15. The overall scores provided the basis for comparing the groups. As in Study 1, the data is relatively normally distributed and there is no obvious lack of homogeneity of variance so the requirements for the application of parametric tests were met (Huck and Cormier, 1996). To test for an effect of each intervention on the subjects, Student's t-tests were applied to the pre and post-intervention data. To test for differences between the three experimental groups a one-way ANOVA was used. Post hoc comparisons were made using Tukey's test.

7.6.2 Degree of Transfer

On the assumption of an additive model of training, it would be reasonable to assess transfer by subtracting the first performance score, i.e. the pre-intervention score from the second, i.e. post-intervention performance score to give a measure of performance that can be related to the intervention. However, given the complexity of factors influencing training, the validity of the additive assumption is questionable, so alternative methods of assessing changes in performance are required.

The amount of transfer was assessed by expressing the difference in the pre and post-intervention scores as a percentage of the maximum possible transfer (given by the difference between the baseline score and the maximum possible score). This comparison
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gives a measure of first shot transfer (Hammerton, 1967). 'First shot' is the immediate benefit or cost of prior experience. In this case the degree of transfer is given by the formula:

\[(\text{Performance score post-intervention}) - (\text{Performance score pre-intervention})\]

\[(\text{Maximum possible performance score}) - (\text{Performance score pre-intervention})\]

7.6.3 Analysis of Planning Data

7.6.3.1 Verbal protocols/behavioural sequences

To provide a check on the behaviours reported within the protocols, as the protocols were collected they were compared with the sequences of behaviour observed on the videorecordings. This means that the videorecordings served to disambiguate utterances, and that the transcribed utterances had at least face validity relative to the observed behaviour. Each protocol was transcribed. The only sections not transcribed were: any inaudible parts and any that were straightforward reiterances. The utterances were classified into one or more of the identified categories of plan formulation, plan updating, and plan failure. Example utterances in each of these categories are:

Plan Formation

'Td noticed the drip and I was thinking how I was going to make sure I was
supporting the patient and hold onto that (the drain) at the same time'

(S3, CT_{rel})

'I asked her to straighten them (her legs) so that it would be easier when we came to actually move'

(S2, CT_{rel})

'I was just trying to get rid of the drain so it wouldn't get in the way during the manoeuvre'

(S2, CT_{rel})

'I'm just trying to move those slippers so she wouldn't catch her feet in them'

(S4, PP)

'I thought I'd better check the area that I'm going to get her out into'

(S3, PP)

**Plan update**

'then I realised I had to move the bedcovers'

(S6, PP)

'she was obviously feeling a bit dizzy so she went flop so I had to quickly rethink my plan'

(S6, CT_{rel})

'she just fainted there so I wanted to just gently lower her back to give her a minute to recover'

(S3, CT_{rel})
Plan failure

'I thought 'Oh dear what shall I do and I found it really difficult to extrapolate from the training on the model to a real situation ....I didn't really have any idea how to approach it'

(S3, PP)

'I didn't work out she was going to end up sitting on it (the drain) and she did'

(S4, PP)

'by then I couldn't move her easily and it was too late to go back and lie her down'

(S1, CT, CT)

'when I got her up and she collapsed it was a complete shock because I hadn't actually thought it through from the beginning....I hadn't even considered that that might happen'

(S6, PP)

'as soon as I'd done it I realised I was trapped'

(S3, CT)

'I didn't think the drain should be in her hands ....but then I had this awful dilemma ...of the fact that she was going to flop over whilst I moved the drain'

(S3, PP)

No grammatical constraints were imposed on the division of the protocol into individual utterances. Hence, an utterance could be of any length. A sentence could contain a variety
of utterances of different types and there were no formal criteria for dividing the protocol. Informal cues included pauses, observations of behaviour on the videos, interpolations into the sentence, and the use of particular words or phrases such as 'because' or 'what I'm thinking'. Utterances related to the technical aspects of the manoeuvre but not obviously related to planning were not classified. An example of this sort of utterance was, 'I'm bending a bit here'. The remaining utterances were also not classified and these were nearly always unfinished utterances.

The classification is a very crude attempt to identify planning utterances. However it makes no claim to be absolute in respect of its exclusive appropriateness for this task nor in the sense that multiple users of it would necessarily produce identical results. As Whitefield (1986) states: 'Assignment of utterances to categories is a matter of judgement'. and, 'the facility to assign them to more than one category is an attempt to negate individual biases in this respect'. Ideally, the classification would have been assessed by comparing the judgments made with those made by multiple raters. This would be feasible. However, as the purpose of this work was not to develop a validated means of analysing protocols, using the judgments of one rater was considered to be acceptable.

One of the principal limitations of verbal protocols is that they only provide partial access to the knowledge used. The relationship between what is spoken and the underlying mental processes is also uncertain. Ericsson and Simon (1984) provide a comprehensive discussion of verbal protocols. According to them, the type of protocol used here, mainly
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involves a Level 2 verbalisation. That is, the information is not necessarily originally encoded in verbal form and must be translated into verbal form in order to be reported. Ericsson and Simon (1984) suggest that there is no evidence that Level 2 verbalisation changes the course or structure of the thought processes involved. In their reporting, subjects are asked to simply report their thought processes and not to explain, filter or selectively attend to them. Obviously, individuals' ability to comply with these instructions varies and may be a further source of error.

7.6.3.2 Questionnaire responses

Subjects' responses to each of the questions were recorded in three categories: Yes, No or Uncertain.

7.6.3.3 Responses to planning probes

The responses assessed are behavioural. Hence, by definition, they are part of the plan, thus the implication is that subjects with a better behavioural response have better updating of their goal stack.

7.6.4 Analysis of Imagery abilities and compliance

Descriptive statistics were used on the data gathered from the movement imagery questionnaire.
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7.7 Results

As in Study 1, the assumptions of normality and homogeneity of variance appeared to be satisfied, so parametric analyses were used, again following the recommendations of Huck and Cormier (1996). P < 0.05 was taken as the criterion for statistical significance throughout. Overall subjects' performances and behaviours benefitted from both relevant cognitive training and additional physical practice, and subjects in both groups evidenced improved transfer. This section presents first the effects of the interventions on performance including the degree of transfer, and second, the results concerning planning behaviours.

7.7.1 Performance data

7.7.1.1 Reliability

The performance data presented here are based on the judgements made by rater 1 on the first rating occasion. Intra-class correlation coefficients were calculated for the performance scores obtained from judgements made by rater 1 on the first and second rating occasions and judgements made by rater 1 on the first rating occasion and those made by rater 2. Both indicated acceptable reliability (see Appendix 4).

7.7.1.2 Pre and post-intervention performance

To test the effect of each of the interventions Students t-test was applied to the difference in the pre and post-intervention performance scores of subjects in each group. Significant improvement in performance occurred in subjects who had undergone relevant cognitive
training (T = 3.84, p = 0.012) and also in those who had undergone additional physical practice (T = 3.46, p = 0.018). However there was no significant improvement in the group which had undergone irrelevant cognitive training (T = 0.54, p = 0.61). The mean pre and post-intervention performance scores are shown in Table 7.0. The individual pre and post-intervention scores appear in Appendix 4.

Using Hammerton's (1967) formula the degree of transfer was calculated. Although the degree of transfer varied substantially between subjects, the $CT_{rel}$ group demonstrated 22.7% transfer on average, compared to 25.4% for the physical practice group, lending partial support to the hypothesis that $CT_{rel}$ would enhance transfer. The $CT_{irrel}$ group was the only group to demonstrate negative transfer of -8.8%.
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Table 7.0

Mean (SD) pre and post-intervention performance scores

| Performance scores | Group A CT_
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-intervention</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>7.0</td>
</tr>
<tr>
<td>SD</td>
<td>1.67</td>
</tr>
<tr>
<td>Post-intervention</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>8.83 **</td>
</tr>
<tr>
<td>SD</td>
<td>1.33</td>
</tr>
<tr>
<td>Degree of transfer</td>
<td></td>
</tr>
<tr>
<td>Mean %</td>
<td>22.7</td>
</tr>
<tr>
<td>SD %</td>
<td>14.1</td>
</tr>
<tr>
<td>Range %</td>
<td>0 - 33.3</td>
</tr>
</tbody>
</table>

** p < 0.05  ns = non-significant  - = negative transfer

To test the first hypothesis that subjects who had undergone relevant CT would demonstrate significantly better performance scores than subjects in other groups a one-way ANOVA (Table 7.1) was performed on the difference scores (F2,17=5.41, p= 0.017).

Table 7.1

ANOVA summary table based on difference in performance scores (post-intervention - pre-intervention score)

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>2</td>
<td>20.33</td>
<td>10.17</td>
<td>5.41</td>
<td>0.017</td>
</tr>
<tr>
<td>Within groups</td>
<td>15</td>
<td>28.17</td>
<td>1.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>48.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

200
Tukey's post hoc comparison of the scores of subjects in Group A ($CT_{re}$) and Group B (PP) indicated that there was no significant difference between the groups ($p < 0.05$). Thus the first hypothesis was partially supported in that relevant cognitive training does significantly improve performance, but does not do so significantly more than additional physical practice.

7.7.2 Compliance with the intervention

The imagery questionnaire revealed few differences between subjects who underwent relevant cognitive training and those that underwent irrelevant cognitive training with respect to the variables of imagery ability and compliance. The data appears in Appendix 4. Similarly there was little variation in the number of lifts performed by subjects in the physical practice group, and they were all close to the target figure indicating adequate compliance.

7.7.3 Behavioural data

The second hypothesis predicted greater improvement in the planning behaviours of subjects in the $CT_{re}$ group compared to subjects in the other groups. In general, the hypothesis was supported, although, as with the performance data, the distinction between the $CT_{re}$ groups and the PP group was small.

7.7.3.1 Responses to planning probes

The responses to the planning probes are shown in Table 7.2. The general trend of the
data indicates that subjects in the $\text{CT}_{\text{rel}}$ and PP groups responded to the probes more adequately than did subjects in the $\text{CT}_{\text{irel}}$ group. Assuming that the probe scale was roughly linear and as the responses were reasonably normally distributed, to test for any differences between the groups, the responses to each probe were tested using a one-way ANOVA. No significant differences were found between the groups (Probe 1: $(F_{2,15}) = 0.26, p = 0.775$; Probe 2: $(F_{2,15}) = 2.55, p = 0.112$). Individual responses to the probes and ANOVA summary tables appear in Appendix 4.

### Table 7.2

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{CT}_{\text{rel}}$</td>
<td></td>
</tr>
<tr>
<td>Probe 1</td>
<td>2.17 (0.75)</td>
</tr>
<tr>
<td>Probe 2</td>
<td>3.17 (0.75)</td>
</tr>
<tr>
<td>PP</td>
<td></td>
</tr>
<tr>
<td>Probe 1</td>
<td>2.0 (1.09)</td>
</tr>
<tr>
<td>Probe 2</td>
<td>2.5 (0.84)</td>
</tr>
<tr>
<td>$\text{CT}_{\text{irel}}$</td>
<td></td>
</tr>
<tr>
<td>Probe 1</td>
<td>1.83 (0.41)</td>
</tr>
<tr>
<td>Probe 2</td>
<td>2.17 (0.75)</td>
</tr>
</tbody>
</table>

#### 7.7.3.2 Verbal protocols

The protocol of one subject in the $\text{CT}_{\text{irel}}$ group was inaudible so was not transcribed.

The number of references to plan formulation, plan updating, and to failed plans was counted. The non-independence of the data precluded statistical analysis. The protocols of subjects in the $\text{CT}_{\text{rel}}$ and PP groups were, in general, longer and contained more plan type references than the protocols of the $\text{CT}_{\text{irel}}$ group. As the protocols varied in length,
the counts are expressed as a percentage of the total number of analysed utterances (Table 7.3). The individual breakdown of utterances appears in Appendix 4. Sample protocols exemplifying the transcription process and the quality of synonyms appear in Appendix 4. As Table 7.3 shows, subjects in the \( \text{CT}_{\text{rel}} \) group made a proportionally similar number of references to plan formulation and update as did subjects in the PP groups. Subjects in the \( \text{CT}_{\text{rel}} \) group also seemed to demonstrate less plan failure than subjects in the PP and \( \text{CT}_{\text{irrel}} \) groups.

**Table 7.3**

**Number and category of protocol references indicating planning**

<table>
<thead>
<tr>
<th></th>
<th>Group A ( \text{CT}_{\text{rel}} )</th>
<th>Group B PP</th>
<th>Group C ( \text{CT}_{\text{irrel}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of plan type references for group</td>
<td>132</td>
<td>122</td>
<td>76</td>
</tr>
<tr>
<td>Average number of plan type references per subject</td>
<td>22</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Number of references indicating plans formulated (%)</td>
<td>56</td>
<td>45</td>
<td>30</td>
</tr>
<tr>
<td>Number of references indicating plans monitored/updated (%)</td>
<td>36</td>
<td>33</td>
<td>36</td>
</tr>
<tr>
<td>Number of references indicating failed plans (%)</td>
<td>8</td>
<td>22</td>
<td>34</td>
</tr>
</tbody>
</table>
7.7.3.3  Question responses

Although the responses to the questions were rather varied as shown in Table 7.4, certain trends were suggested. Firstly in response to Question 3 (Did you think in advance what you were going to do from the beginning to the end of the task?), in the CT_{md} and PP groups, four and three subjects respectively responded affirmatively. In contrast, only one subject in the CT_{md} group responded positively. Similarly, in response to Question 5 (Did you think in advance about any part of the task?), all but one subject in the CT_{md} and PP groups responded positively, whereas only two subjects in the CT_{md} group responded in this way.
Table 7.4

Responses to questions

<table>
<thead>
<tr>
<th>CT_{rel} Group</th>
<th>Questions</th>
<th>Y</th>
<th>N</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you anticipate any difficulties in executing the task.</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Did you think a lot of effort was required</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Did you think in advance what you were going to do from the beginning to the end of the task.</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Did this task turn out to be more difficult than expected</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Did you think in advance about any part of the task</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

| PP Group       | Questions                                                           | Y | N | U |
|----------------|                                                                    |---|---|---|
| 1              | Did you anticipate any difficulties in executing the task.         | 2 | 2 | 2 |
| 2              | Did you think a lot of effort was required                          | 3 | 1 | 2 |
| 3              | Did you think in advance what you were going to do from the beginning to the end of the task. | 3 | 1 | 2 |
| 4              | Did this task turn out to be more difficult than expected          | 4 | 0 | 2 |
| 5              | Did you think in advance about any part of the task               | 5 | 0 | 1 |

<table>
<thead>
<tr>
<th>CT_{irrel} Group</th>
<th>Questions</th>
<th>Y</th>
<th>N</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you anticipate any difficulties in executing the task.</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Did you think a lot of effort was required</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Did you think in advance what you were going to do from the beginning to the end of the task.</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Did this task turn out to be more difficult than expected</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Did you think in advance about any part of the task</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Key:  Y = yes  N = No  U = Uncertain
7.8 Discussion

7.8.1 Overview

The results indicate that the model developed from the findings of Study 1 has been successful to the extent that it has supported the prescription of training enhancements which have reduced the problem of ineffective training identified in Study 1. However, this reduction was effected by two of the interventions, relevant CT and additional physical practice. The main finding was therefore, that contrary to the model's predictions, there are two solutions which produce a reduction in the problem of transfer, and they appear to do so to broadly similar extents. Thus, the predictions made from the model about the effectiveness of different enhancements were partially supported, relevant CT does support transfer but, less expectedly, so does additional physical practice to a similar extent. The discussion will begin by identifying possible reasons for, and factors to be considered in relation to the specific results by considering each of the dependent variables. This will be followed by discussion of the relationship of the behavioural and performance findings and the more general implications of the data with respect to the model.

7.8.2 Specific results of study

As behaviour(s) supports performance, in the following discussion, consideration of the behavioural data precedes discussion of the performance data.
7.8.2.1 Planning and protocols

The post-intervention performance scores showed a significant difference between subjects in the groups which underwent relevant CT or PP, and subjects in the group which experienced irrelevant cognitive training. Overall, the pattern of the behavioural data suggests that subjects in the CT\textsubscript{rel} and PP groups demonstrated more and better planning than those in the CT\textsubscript{irrel} group. Subjects in the CT\textsubscript{irrel} group evidenced little, or poor quality planning. The results also suggest, albeit rather less clearly, that subjects in the CT\textsubscript{rel} group demonstrate more and better planning than those in the PP group. In relation to the model the implication is that planning and execution (performance) may be more closely associated in the CT\textsubscript{rel} group than in the PP group. This will be explored further in section 7.8.3.

The retrospective protocols used to assess the behaviours occurring may have been subject to error as subjects provided a post-hoc rationalisation of their actions, planned or unplanned. However, Ericsson and Simon (1984) have suggested that such error is markedly reduced when videorecordings and protocols are used together, and it is hoped that error was minimised by the visual cueing and corroborative evidence provided by the videorecordings. Analysis of protocol data is also reliant on some inference by the analyst and this may have been a further source of error. Furthermore, using percentage transformation of the protocol data to control for protocol length is also problematic as the percentage has limited range and is asymptotic. Consequently, the resulting measurement is not linear rendering any comparisons made only approximate.
Apart from methodological difficulties associated with the use of protocols, the assessment of planning is particularly challenging in a domain which lacks automatically accessible evidence of planning behaviour. In this respect, the patient-handling domain contrasts starkly with, for example, the domain of medical reception, where diaries and planning sheets are a routine part of the work and have facilitated assessment of planning (Hill, Long, Smith and Whitefield, 1995). All of the methodological concerns mandate that the protocol data be treated cautiously in any attempt to understand the behavioural differences between the groups.

7.8.2.2 Probes

The responses to the planning probes suggested that, in general terms, subjects in both the CT_{rel} and PP groups responded more adequately to unexpected events than did their counterparts in the CT_{int} group. However, there was little difference between the CT_{rel} and PP groups in their responses to the probes. In terms of the model this may indicate that at least some aspects of planning are similar in these two groups. Although the expectation was that subjects in the CT_{rel} group would respond more favourably to an event which, if not likely, was at least reasonably foreseeable, than to one which they could not reasonably have foreseen, this was not evidenced. This may have reflected a methodological lack of sensitivity or it may have been because the order of presentation of the probes was not randomised. However, the individual response scores do not indicate any obvious learning effect and the use of planning probes does seem to provide one, albeit crude, means of accessing plans.
7.8.2.3 Questions

The data obtained from the questions was only intended to assist in relatively crude assessment of subjects' plans. The first two questions (1. Did you anticipate any difficulties in executing the task? 2. Did you think this was a task requiring a lot of effort?) which aimed to identify general evidence of a plan, seemed to indicate less planning by subjects in the CT_inrel group. Responses to Question 2 showed that it was mainly the subjects in the PP group who felt the task was effortful. It seems likely that this reflects a poorly designed question where subjects could interpret effort as an essentially physical phenomenon rather than anything more akin to mental workload. This question will not be discussed further. Similarly, Question 4 (Did the task turn out to be more difficult than expected?) was intended to assess the quality of subjects' plans, yet nearly all subjects in all groups responded affirmatively probably reflecting the lack of sensitivity within the question.

Question 3. (Did you think in advance what you were going to do from the beginning to the end of the task?) concerned with seeking evidence of plan formulation, was more successful. The responses suggest that subjects in both the CT_rel and PP groups were more likely to think in advance about what they were going to do than those in the CT_inrel group. Finally, Question 5. (Did you think in advance about any part of the task?) indicated strongly a difference between subjects in the CT_rel and PP groups who almost universally claimed to have thought in advance about some part of the task compared to the CT_inrel group where only two subjects made such a claim.
7.8.2.4 Performance scores

Following intervention, the performance scores of the control group $CT_{incl}$ remained relatively unchanged, whereas the scores of both the $CT_{rel}$ group and the PP group evidenced significant improvement. These findings indicated that contrary to the model's predictions both enhancements benefitted performance.

The raw data suggested that there was little difference between the $CT_{rel}$ and PP groups, so it was not possible to conclude that cognitive training is significantly better at enhancing performance than extra physical practice, at least in the short term. This is further supported by the similarity between the degrees of first shot transfer evidenced by the $CT_{rel}$ group (22.7%) and the PP group (25.4%). Investigation of the comparative robustness of each intervention across time might provide a basis for distinguishing the interventions and for subsequent development of the model. Clearly this merits future investigation.

Why were the results of these two groups more similar than expected? Firstly, it is possible that differences in motivation account for the different results. Subjects who underwent either of the CT interventions may have reacted negatively to an intervention which they had not previously experienced, and which perhaps appeared to have little relevance to them. Although the subjects were blind to the study's specific purposes, it is not unreasonable to suggest that subjects who underwent additional physical practice felt that they needed to 'prove' themselves on the post-intervention test, and were therefore,
more motivated than their cognitively trained counterparts. Although assessment of subjects' motivations may have identified this, there is nothing in the compliance data to suggest that profound motivational differences existed between the groups. However, assessment of motivation is extremely difficult (Birney and Teevan, 1962) and possible motivational differences must be acknowledged as at least forming a possible part of an explanation for the results. Certainly, a motivational explanation for the findings endorses Paivio's (1985) suggestion that, in sport, the effects of cognitive training may be mediated through motivation.

The suggestion thus far has been that psychological or psychosocial reasons may explain the differences between the CT_{rel} group and the PP group. However, it is possible that the differences can be explained by physical changes either actual or perceived. Thus subjects in the PP group may have become more fatigued as the training protocol advanced, producing lower performance scores, or else they may have become fitter contributing to higher scores. In the absence of data such as ratings of perceived exertion neither possibility can be excluded. All of the subjects in this study were, however, physically fit and had already had previous manual handling experience. Thus, given the amount of physical training contained in the protocol, it seems unlikely that this would have had a measurable effect on already fit people.

The most obvious explanation for the lack of statistical difference between the CT_{rel} and PP groups, i.e. that the sample size was just too small, may not be the most likely given
that the difference between the mean scores of the CT_{rel} and PP groups was small. However, the inherent variability in subjects' performances of a complex task may necessitate the development of more sophisticated measures of behaviour and performance if differences are to be detected. Linked to the issue of variability is the notion that what constitutes enhanced training varies among individuals. This may, in turn, partially link to the notions of motivation discussed above. In a more general sense, it allows for different people to find different training methods beneficial. If this is indeed the case then the need is to identify those individual characteristics which might interact with the model to predict optimal individual training enhancement.

7.8.3 General discussion/implications

The verbal protocols provided only a crude means of interpreting the performance data and the information they provided should be viewed in that light. Yet, despite the concerns mentioned in relation to the use of verbal protocols, it was reassuring to find that many of the utterances identified as plan indicants in the informal pilot work reemerged in this study. Consideration of the behaviours supporting performance indicated that subjects who had undergone relevant cognitive training or additional physical practice made more 'plan type' references than subjects who had received irrelevant cognitive training.

Apart from differences in the number of overall plan type references, there were also differences in the relative proportions of references in each of the categories concerned with plan formulation, plan updating, and references indicating plan failure. Proportionally
more of the utterances made by subjects in the CT_{rel} and, to a much lesser extent, in the physical practice group, referred to plan formulation in comparison to the CT_{irrel} group. This may indicate that the two former groups had been supplied with knowledge which supported plan creation although the precise nature of these plans, and hence any differences between the groups in this respect, were not identified. Subjects in the CT_{rel} group also showed less evidence of plan failure than did subjects in the CT_{irrel} and PP groups. Although it would be unwise to overinterpret this, it is tempting to suggest that subjects in the CT_{rel} group created better plans than those in the PP group. This raises the question of how, given that many of their plans failed, were subjects in the PP group able to perform so well? Presumably, unlike subjects in the CT_{rel} group, those who had undergone PP could respond to their failed plans more adequately. Certainly, it would seem that, at some level, additional physical practice provided subjects with some support to planning.

There is one caveat to the discussion so far. The assumption has been that by using a reasonably well controlled experimental design the differences between the groups can be attributed to the interventions tested. However, planning behaviour is in many ways a nebulous phenomenon, difficult to clearly observe and analyse and almost certainly sensitive to recognised and unrecognised influences. For example, the relationship of the state of the environment to an individual may have varied according to the intervention they received, or merely due to individual factors. Thus, the prompting to planning, be it formulation or update, triggered by the different states of the environment present in a
dynamic task, remains uncertain.

In exploring the role of different environmental states, it is appropriate to consider the views of proponents of non-representational approaches to motor control (e.g. Kugler, 1986; Turvey, 1990) who suggest that much of movement control proceeds in a bottom-up manner, as a direct consequence of the physical characteristics of the performer and task, rather than as a result of prescriptive cognitive control. Traditionally, there has been a distinction between representational and non-representational approaches to control, and indeed in the context of manual handling the role of each tradition has been discussed (Burgess-Limerick and Abernethy, 1993). Yet, in relationship to the findings of the present study, it seems erroneous to labour the distinction. Rather, the matter seems to be a question of emphasis. On the one hand there is evidence that subjects do intentionally form a representation of the environment (which incorporates knowledge concerning the task requirements and subjects' own physical attributes) and of their intended actions. On the other hand in a dynamic situation the physical attributes change. These changes may or may not be fully reflected by a change in plans, i.e. plan update. The implication to the findings of the present study is that the addition of PP affects performance partially via enhanced planning but may affect performance via a direct link between perception and action. The latter is consistent with the claim of non-representational proponents who consider that perception and action are reciprocally causally related (Gibson, 1979).

Two further interesting findings were identified. Firstly, not only did subjects in the CT_{rel}
group make fewer plans, but the plans may also be presumed to be poorer in quality as evidenced by the markedly larger number of failed plans. This suggests that these subjects may have lacked adequate support for creating plans. The second finding was that subjects in all groups showed evidence of plan updating/monitoring albeit to varying extents. On the basis of the performance scores it can be presumed that plan updating and monitoring was more efficient in subjects in the CT_{me} and PP groups compared to that of subjects in the CT_{rel} group. Furthermore subjects in the PP group made proportionally less plans and evidenced more plan failure than those in the CT_{rel} group so it may be that the achievement of comparable performance scores can be attributed to efficient plan updating and monitoring.

The results for the physical practice and CT_{rel} groups were more similar than expected. Many authors (e.g. Lee and Magill, 1985; Reeve and Manoir, 1983) have suggested that transfer performance is facilitated to the extent that the feedback conditions during transfer match the feedback conditions available during practice. Although the overt feedback is very different for the two interventions, it may be that the critical elements of feedback, for example, the suitability of recruiting a particular behaviour at a given point in time, were captured by both of them.

Assuming that both groups did benefit by being able to increase compatibility between the practice and transfer conditions, it may be that, whereas the performance of subjects who had undergone physical practice suffered in the transfer test, when feedback was not
available, subjects in the CT_{ret} group had processed the feedback in a way that continued to be beneficial. This is a little speculative, but is consistent with Salmoni et al's (1984) view that the role of feedback in physical practice may be to guide performance under some acquisition conditions rendering performance poorer on transfer when the same guidance is not available.

It is also plausible that the representations formed by the PP group are more similar to those formed by the CT_{ret} group than expected. Thus, in terms of the model, whereas the prediction was that relevant cognitive training would offer more support to the knowledge of tasks representation than additional physical practice did, this may not have been unequivocally the case. It was originally argued that additional physical practice might have a negative effect on transfer on the basis of supporting the original default set of plans engendered by STP. As the following excerpt from the protocol of a subject in the PP group shows this was partly supported:

'I just went into kind of automatic mode (default plan) which I'd learnt to get someone from lying up to sitting so I wasn't really thinking much about what the patient could actually do for herself, what her own state was' and 'I was again very much, I feel, going very much along what I'd been taught (default plan) rather than thinking things through'

(S6, PP)

However, it may be that the enhanced training, by providing two additional defaults, diluted the effect of default 1, if only by increasing the number of defaults to select from. On this basis, subjects' performances on the transfer test might improve partly because the relative influence of their previous training is diminished, and partly because the additional practice supports the lower level features of the execution process.
The failure of the CT\textsubscript{rel} group to produce any change in performance could be attributed to differences in subjects' compliance with the intervention. However, the absence of a significant difference between the imagery scores does not support this, nor does the data concerning compliance with the physical practice instructions.

To summarise, the subjects who received relevant cognitive training demonstrated improved planning behaviours, which supported better performance scores on transfer, supporting the hypothesis that relevant CT improves actual performance. The model's predictions that the intervention would provide a generic goal structure able to support a larger number of specific instances of manual handling were also supported, but the predicted zero effect of additional physical practice was refuted.

In conclusion, the data indicates that subjects in both the CT\textsubscript{rel} and the PP groups showed performance improvements and, furthermore, the three components comprising the assessment of behaviours do, in combination, point to differences between the groups. Behavioural assessment is methodologically difficult and certainly this study has highlighted the need for further work to develop better, more clearcut, indicants of the existence of plans. Nevertheless, given that the behavioural differences exist alongside differences in performance, it seems reasonable to suggest that both relevant cognitive training and additional physical practice support planning, and that supported planning is central to enhanced transfer.
Chapter 7: Study 2

In terms of transfer, subjects who had undergone relevant cognitive training showed enhanced amounts of transfer. In terms of the model this indicates that by supporting better planning, subjects were able to formulate a more appropriate goal stack and were able to satisfy it by appropriate behavioural selection. To a lesser extent the same view can be advanced for subjects who received additional physical practice. Unsurprisingly, subjects in the CT_{ins} group showed a small amount of negative transfer perhaps reflecting the predicted difficulty subjects have in deciding and executing an appropriate set of behaviours.

Despite the unexpected benefits of additional physical practice, the identification of relevant cognitive training as a potentially useful enhancement to the training programme is, in some ways, arguably, of more practical significance. There are several reasons for arguing this. First, although subjects in this study received face to face supervision of the cognitive training, once subjects have learnt the techniques this may not be necessary, facilitating savings in terms of time and cost. Secondly, physical practice cannot always be undertaken by people, for example, if a person has a wrist, shoulder or back problem. Cognitive training provides a means for some training to be continued. However, in order to realise these practical benefits it is necessary to know how long the effect lasts. For example, does cognitive training affect acquisition in a permanent way or is this 'permanence' contingent on intermittent 'top ups', and if so at what sort of frequency.
7.9 Summary and Conclusions

This study has empirically demonstrated the utility of the modified MMAC model in supporting an effective prescription for an enhanced training programme. In relation to the details of the prescription, the experimental findings have confirmed the possible roles of both relevant cognitive training and additional physical practice in supporting transfer of patient-handling skills and have provided a basis for refinement of the model. Furthermore, the evidence obtained is suggestive of transfer to the real world. A logical next step is to assess whether the refined model has a wider applicability. This is the central concern of Chapter 8.
Chapter 8

STUDY 3: APPLYING THE MODEL MORE GENERALLY

8.1 Chapter overview

Chapter 2 documented the requirement for enhanced training of patient-handling. Subsequent chapters offered the MMAC-PH model as a means of reasoning about possible enhancements to the training programme, culminating in the testing of the utility of the model in the context of one population in Chapter 7. Chapter 8 aims to begin investigation of the utility of the model in a more general sense, by addressing its use in a different population of novices, namely those with an experience of LBP. The chapter begins by considering, in general terms, definition of the problem and its relation to the MMAC-PH model. It then considers the potential for using cognitive training, as prescribed by the model, as an enhancement to the training programme. The chapter describes an empirical study in which the enhancement is investigated. Chapter 8 concludes with consideration of how the model might be used more widely.

8.2 Defining the problem

The previous chapters have described the evidence for the ineffectiveness of training in patient-handling and the investigation of a rationalised solution suggested by use of the MMAC-PH model. However, the utility of the model thus far is limited to a particular set of subjects, trained in a particular way, and engaged in patient-handling tasks, raising the question of whether or not the model can be used more widely. There are a number of
ways, at different levels of generality, by which this question could be addressed. For example, transfer could be considered in relation to other applications, other manual handling programmes, or other classes of novice:

1. training subjects for other areas of non-patient manual handling, e.g. industrial lifting tasks, everyday manual handling tasks
2. training subjects for different i.e. non-manual handling tasks, e.g. sporting tasks
3. training subjects who differ in some way which might affect the optimal design of the training programme for either 1. or 2. For example, people with different types of medical knowledge such as hospital porters.

The work presented in this thesis sets out to provide support to the rational development of patient-handling training programmes for physiotherapists. The general aim of such training programmes is to induce in the trainee a set of behaviours compatible with the minimisation of work-related LBP. Hence, the attempted generalisation used a different population of novice physiotherapists performing patient-handling tasks, i.e. option 3. The population in this study differed in that the subjects had a recent experience of back pain. The two populations had many features in common, and in a sense, this reduces the extent to which the study described in this chapter is able to validate the model. On the other hand, the population chosen differed in critical aspects which the MMAC-PH model was able to differentiate, it had the advantage of providing systematic control to allow exploration of the generality of the model. Furthermore the populations were different in a respect which was highly salient to the overall aims of the training programme.
The experience of LBP has several implications for physiotherapists whose work is, by definition, highly physical. Many of the activities physiotherapists are required to perform, including patient-handling tasks, are potentially aggravating to a person with experience of low back dysfunction. Clearly, it is important that any training offered to such people does not exacerbate their back problem. For people who have experienced LBP and acquired a predisposition to further attacks of pain, the potential costs of non-compliance with taught principles are even higher than to the pain-free population.

Whereas it might be expected that people with an experience of back pain would demonstrate better transfer of their knowledge than normals, if this is not the case, i.e. if transfer is equal to, or worse than that of normals, the costs to people with LBP are potentially very high. For example, individuals may sustain progressively more serious damage, or may become sufferers of chronic pain. The requirement for such individuals to effectively transfer their taught patient-handling skills is perhaps even more crucial than that for their normal counterparts. Indeed, the therapeutic management of such individuals often relies on advising them about ways of moving and handling in everyday life. The principles upon which patient-handling is based, are applicable to a wide variety of everyday manual handling situations. Hence, these principles are commonly incorporated into the therapeutic and prophylactic advice given to LBP sufferers. Patient education is often configured into formal programmes designated as back schools (for a review, see Koes, van Tulder, van der Windt and Bouter, 1994), aspects of which are not dissimilar to patient-handling training programmes.
8.3 LBP and the MMAC-PH model

The study described in Chapter 7 demonstrated that the problem of poor transfer of learned patient-handling skills could be reduced in novices who had not recently experienced LBP. Given that patient-handling programmes exist primarily to reduce the likelihood of back injury in novices, one of the main defining characteristics of novices may be the existence or not of an experience of LBP at the time of, or subsequent to training. In the context of the model, such novices could be particularly aware of potentially damaging situations, i.e. they would be likely to have a different set of perceiving behaviours and hence potentially different contents of their knowledge-of-tasks compared to their counterparts with no experience of pain. For example, the person who is, 'fearful for his back' may overestimate, or inaccurately estimate potential hazards leading to a defective knowledge-of-tasks (KOT) and consequent defective plans. In terms of the MMAC-PH model, although it is possible that the actual perceptual structures themselves are different as compared to the pain-free population, it is perhaps more likely that the perceptual process differs. The nature of the difference between people with an experience of LBP and those without might be presumed to influence subjects' compliance with training. The implication is that a different intervention might be prescribed by the model.

To summarise, it seems reasonable to assume that the experience of LBP may change the way people respond to a training programme. This therefore needs to be addressed in the development of a solution to the problem of an ineffectively designed training programme which may be different to that appropriate for 'normal' handlers.
8.4 Developing a solution

The proposed solution takes the form of an enhanced training programme. To recap, the possible manner in which transfer could be optimised and the training programme enhanced is again derived from predictions made by the model. The model contains hierarchical knowledge structures and postulates that transfer can occur in two ways: either by instantiation from high level knowledge or via generalisation from low level knowledge. Both methods of transferring knowledge, i.e. instantiation and generalisation involve the novice in making some form of comparison between the existing knowledge and that required. In terms of the model, the principal difference between people with an experience of back pain and those without is likely to be in the contents of their knowledge-of-tasks or in its format. For example, people with an experience of LBP may have different self-knowledge which may result in their structuring their knowledge of domain objects differently. Differences in the knowledge-of-tasks are likely to lead to differences between back pain sufferers and their normal counterparts in the plans formulated.

The model suggests that the existing training programme, supports the acquisition of a generic goal and behavioural structure. It also supports a few specific task instances in which a small set of specific behaviours are linked to a goal structure. The latter can be considered to be the default structure. The suggestion was that in non-taught patient-handling situations, trainees revert to the default structure, at least partially, leading to the recruitment of behaviours inappropriate to a particular situation. Some support to this view was offered by the protocol data obtained from subjects in Study 2. In LBP sufferers,
inappropriate behaviours may be recruited by a worksystem which is inherently more vulnerable to the costs incurred.

From the model, the problems experienced by LBP sufferers in transferring their training may be related to their representations of both knowledge-of-tasks and of plans. Hence this is where the solution should be targeted. Thus support is required not only for planning but also for perceiving and the structuring of the knowledge contained within the knowledge-of-tasks. To facilitate the translation process, mediated via planning and control behaviours, an enhancement to the training programme is sought that will simultaneously combine the operationalisation of high level knowledge with the generalisation of low level knowledge. Working from the premise that both the knowledge-of-tasks (KOT) and the plans will be strengthened by practice, it is suggested that an intervention is needed which allows both of these representations to be evaluated and/or enhanced and/or refined with respect to specific instances of patient-handling.

Thus the solution aims to support the formulation of plans and of the KOT representations which facilitate the formulation of a goal structure appropriate to the setting, where appropriate is defined as a structure which recruits an appropriate configuration of behaviours.

8.4.1 Selection of cognitive training

It has been suggested that trainees with an experience of LBP are likely to have a different perceptual processing and hence different KOT compared to those with no such
experience. So subjects may perceive different stimuli or may process information differently so that they attach different significance to stimuli. On this basis, a solution is required in which perceiving is supported. Two means of support can be conceived. First, strategies designed to draw subjects attention to the detection of relevant stimuli, and second, support afforded to the structuring of this knowledge within the knowledge-of-tasks.

From the relationship between possible solutions and the model, the suggestion is that the training programme could be enhanced by the inclusion of either some form of cognitive training or by the inclusion of additional physical practice. Study 2 unexpectedly found that increased physical practice did in fact support better performance. This was partially attributable to better planning, rendering additional physical practice a likely possible solution to the present problem. Furthermore, in subjects with back pain, additional physical practice provides more intrinsic kinaesthetic feedback which may improve the knowledge-of-tasks. However, the model suggests that PP may support enhanced quality of low level representations and may indirectly support planning, but it is less likely to influence perceiving behaviours and the knowledge-of-task representation. Obviously additional physical practice may be associated with increased risk of injury in subjects who already have experienced some form of damage to the back.

Cognitive training (CT) was previously defined as the provision of support to subjects' representations of plans, where a plan is the intentional representation of the specification of either the required domain states or of the intended behaviours.
Chapter 8: Study 3

In the context of trainees with experience of LBP, the definition needs to be expanded to include provision of support to the knowledge-of-tasks. As previously detailed, it includes, among others, the use of analogies, intrinsic and extrinsic feedback and mental imagery. The model does not prescribe a different intervention for a population of subjects with a back pain experience. Given that the model appears able to distinguish between the populations, it is likely that the prescription of a similar solution may reflect the limited battery of interventions currently available rather than the model's lack of resolution.

The selected form of cognitive training is again mental imagery for the following reasons:

i) it is predicted to support perceiving by providing a means against which trainees can evaluate their KOT and relate it to plan formulation

ii) it is predicted to support planning and control, by providing a means by which trainees can retrieve their default plans and, 'run through' the likely outcome of applying the default, thus providing a basis from which the default can be evaluated and refined for the particular situation.

iii) mental imagery intrinsically involves the representations developed by the processes of the visual perceptual system and simultaneously the processes of verbal coding, therefore offering potential for substantial support to the knowledge-of-tasks
Mental imagery as used in the previous study allows trainees to combine the formulation of plans with a particular set of contents in the KOT. It also allows trainees to retrieve their default plans from memory and to evaluate them in different contexts. By combining visual and verbal inputs with the formation of plans in the imagined situations, mental imagery has the potential to enhance the knowledge-of-tasks and thus indirectly enhance plans as well as to offer direct enhancement of plans.

8.4.2 Summary

To summarise, the model predicts that the addition of cognitive training will support perceiving and planning behaviours leading to the formulation of a goal structure appropriate to a non-taught situation, and recruitment of appropriate behaviours to satisfy this goal structure. Conversely, the model suggests that the addition of physical training will support the implementation aspects of performance but will have no or less effect on planning and perceiving. As the control and implementation aspects are not the ones previously identified as deficient, any improvement of performance is only predicted to the extent that planning is improved.

8.5 STUDY 3

8.5.1 Background and Rationale for study

The previous section noted that the problem demonstrated in Study 1 of the failure of trainees to transfer behaviours learnt in the classroom context to the workplace applies equally to people with LBP, and may be potentially more costly to them. Indeed, the
subject population of Study 1 comprised people both with and without an experience of LBP. It has been suggested that the experience of pain may change a trainee's response to a training programme via the knowledge-of-tasks. It has also been suggested that the addition of cognitive training may help to reduce the problem.

In normal subjects (those without an experience of LBP), it has been suggested that CT is effective mainly by directly supporting plan formulation and updating, and by indirectly supporting the KOT. In people with LBP, the suggestion is that CT additionally offers direct support to the KOT which subsequently influences planning. As previously identified, the solution will take the form of an enhanced training programme which, as in Study 2, attempts to provide trainees with knowledge enabling them to more effectively transfer knowledge acquired in the classroom to novel patient-handling tasks in the simulated workplace.

Study 3 considers the effect on transfer of two solutions, namely, cognitive training and additional physical practice. As Study 2 convincingly demonstrated the absence of any effect attributable to irrelevant cognitive training, a third control group was not included in this study. Consideration of the effect of the solutions on transfer required assessment of both performance and perceiving and planning behaviours.
8.5.2 Aim of study

The aim of the study was:

to investigate whether trainees, with an experience of LBP, who are
supplied with knowledge missing from the training programme, via relevant
cognitive training (CT), achieve better transfer of knowledge to support
their behaviours in non-taught patient-handling situations than trainees who
receive alternative additional knowledge.

The missing knowledge is that which is postulated to support the perceiving, planning and
control behaviours of the trainee.

8.5.3 Experimental Design and Procedure

The design and procedure were essentially the same as used in Study 2 although only two
experimental groups were used. However, an additional measure was made of
performance in an attempt to access perceiving behaviours. Thus there were three
dependent variables:

a) patient-handling performance (assessed using checklist)

b) planning behaviours

c) accuracy of perceiving behaviours

Perceiving behaviours were assessed by the use of self-reports of performance. Troup and
Rauhala (1987) have used students' self-evaluations and found them to be comparable to
the judgments made by independent assessors. Although no claims can be made regarding
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exactly what dimensions are embodied in subjects' self-reports, such reports can be presumed to demonstrate, in some measure, subjects' ability to perceive their own performance. The self-reports were made by asking subjects to assess their own performance using the same checklist used by the independent rater. The judgments made were compared to the independent rater's judgments. The difference between a subject's self-report and the judgment made by an independent rater was used to indicate difference in the accuracy of the contents of the knowledge-of-tasks.

8.5.4 Hypotheses

The results of Study 2 were only partially consistent with the model's predictions indicating that the model may need further refinement. To reflect the results of Study 2, three two-tailed experimental hypotheses were formulated.

1. The addition of cognitive training (CT) to the training programme will enhance performance. The addition of physical practice to the programme will mainly support implementation behaviours and to a lesser extent control behaviours and will also enhance actual performance to a lesser extent.

H₁ There will be a difference between the performance scores of subjects who have undergone CT compared to those who have undergone additional physical practice.

H₀ There will be no difference between the performance scores of subjects who have undergone CT compared to those who have
2. The addition of CT to the training programme will support trainees' perceiving behaviours and hence their KOT, leading to better performance.

\[ H_1 \] There will be a difference between the accuracy of self-reported performance scores of subjects who have undergone CT compared to those who have undergone additional physical practice.

\[ H_0 \] There will be no difference between the accuracy of self-reported performance scores of subjects who have undergone CT compared to those who have undergone additional physical practice.

3. The addition of CT to the training programme will support trainees' planning behaviours and hence improve performance.

\[ H_1 \] There will be a difference in a qualitative sense between the number and type of planning behaviours of subjects who have undergone CT compared to those who have undergone additional physical practice.

\[ H_0 \] There will be no difference in a qualitative sense between the number and type of planning behaviours of subjects who have undergone CT compared to those who have undergone additional physical practice.
8.5.5 Subjects

Subjects (n = 12) were recruited in the same manner as in the previous study. All were female, undergraduate physiotherapy students. Three of the subjects were suffering from some degree of LBP at the time of being trained but it was not sufficient for them to be absent from their studies. All subjects had experienced at least one episode of LBP in the last year. LBP was defined as any condition of ache, discomfort or stiffness occurring in the lower back and lasting for a period of three days or more. A brief history of the behaviour of subjects' back pain was taken as this may have influenced their response to training. This included information concerning: pain nature and severity; area of pain; known aggravating activities.
### 8.5.6 Summarised experimental schedule

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<td>2. Group B, Physical practice - using 2 tasks</td>
<td></td>
</tr>
<tr>
<td>Data collected</td>
<td>Performance - independent raters using validated checklist (to support test of H\textsubscript{1})</td>
<td>Compliance - Group A: imagery questionnaire (to check/test subjects ability to form images and their compliance with CT)</td>
<td>Performance- independent raters using checklist</td>
</tr>
<tr>
<td></td>
<td>Behaviours - identified from a) videos</td>
<td></td>
<td>Behaviours - identified from a) videos</td>
</tr>
<tr>
<td></td>
<td>b) retrospective protocols</td>
<td></td>
<td>b) retrospective protocols</td>
</tr>
<tr>
<td></td>
<td>c) self-reports</td>
<td></td>
<td>c) questionnaire (to support tests of H\textsubscript{1} and H\textsubscript{2})</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>d) self-reports</td>
</tr>
</tbody>
</table>

### 8.5.7 Data analysis

#### 8.5.7.1 Analysis of Performance/Planning Data

Performance data, planning data, and degree of transfer were assessed in the same way as in Study 2. However, in view of the acceptable inter-rater reliability demonstrated in
that study, judgments of the videos were made by one rater only. Data obtained from the movement imagery questionnaire were also treated in the same way as in Study 2.

8.5.7.2 Analysis of data concerning perceiving behaviours

Each subject's self-rating of her overall performance was subtracted from their actual performance score awarded by the rater. On the assumption that judgment of performance is a component of general perception, this measure was used to assess the level of accuracy of a subject's perceiving behaviours.

8.6 Results

This section presents firstly the effects of the interventions on performance including the degree of transfer, secondly the results concerning perceiving behaviours and, thirdly, the results concerning planning behaviour. All statistical tests were two-tailed. P < 0.05 was taken as the criterion for statistical significance.

8.6.1 Overview

Overall subjects' performance scores and their planning behaviours improved with both relevant cognitive training and additional physical practice, and the improvements were reflected in enhanced transfer. Subjects' perceiving behaviours were unchanged.
8.6.2 Performance data

8.6.2.1 Pre and post-intervention performance

Pre-intervention performance data was obtained for 12 subjects. However one subject from the CT group withdrew during the experiment for health reasons, so post-intervention data was collected for 11 subjects. Student's t-test was applied to the difference between the pre and post-intervention performance scores of subjects in each group. The improvement which occurred in the CT group just failed to reach statistical significance ($T = 2.53, p = 0.065$), with one subject's performance deteriorating following training. In the group which undertook additional physical practice no subject evidenced worse performance post-intervention and more significant improvement occurred ($T = 3.51, p = 0.017$). The mean pre and post-intervention performance scores are shown in Table 8.0. The individual pre and post-intervention scores appear in Appendix 5.

Table 8.0

<table>
<thead>
<tr>
<th>Performance scores</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CT</td>
<td>PP</td>
</tr>
<tr>
<td>Pre-intervention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>SD</td>
<td>1.67</td>
<td>2.19</td>
</tr>
<tr>
<td>Post-intervention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>10.4</td>
<td>10.67</td>
</tr>
<tr>
<td>SD</td>
<td>3.71</td>
<td>1.86</td>
</tr>
</tbody>
</table>

Unrelated t-tests revealed no significant differences between the groups' baseline scores
or their post-baseline scores.

8.6.2.2 Degree of transfer

The second hypothesis suggested that increased compliance with taught procedures, i.e.
 improved transfer would occur in subjects who underwent CT. The degree of transfer did
 not vary substantially between the groups (CT: mean = 42.5%, sd = 40.5%; PP: mean =
 36%, sd = 28.2%).

8.6.3 Compliance with the intervention

The results of the imagery questionnaire are shown in Appendix 5. There was little
 variation in the number of lifts performed by subjects in the physical practice group and
 they were all close to the target figure indicating adequate compliance.

8.6.4 Behavioural data

The second and third hypotheses predicted greater improvement in the perceiving and
 planning behaviours respectively of subjects in the CT group compared to subjects in the
 PP group. In general, both hypotheses received some level of support, although the
distinction between the CT group and the PP group was greater in respect of the
perceiving behaviours.

8.6.4.1 Self-ratings

Three subjects, one in the CT group and two in the PP group found rating their own
performance too difficult and felt unable to comply with the request. The data presented
is based on the responses of the remaining 9 subjects (see Appendix 5). The mean pre and post-intervention accuracy scores appear in Table 8.1.

Table 8.1

Mean (SD) accuracy of self rating scores pre and post-intervention

<table>
<thead>
<tr>
<th>Accuracy scores</th>
<th>CT&lt;sub&gt;rel&lt;/sub&gt;</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-intervention</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.8</td>
<td>2.75</td>
</tr>
<tr>
<td>SD</td>
<td>1.48</td>
<td>1.26</td>
</tr>
<tr>
<td><strong>Post-intervention</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.25</td>
<td>2.5</td>
</tr>
<tr>
<td>SD</td>
<td>1.26</td>
<td>1.0</td>
</tr>
</tbody>
</table>

To test the second hypothesis that the accuracy of perceiving behaviours would be better in subjects who had undergone relevant cognitive training, the differences between the pre and post-intervention (obtained by subtracting the post-intervention score from the pre-intervention scores) accuracy scores for each group were assessed using t-tests. Although the raw data indicated a trend towards greater improvement in accuracy in the CT group, neither group evidenced a statistically significant improvement (CT group, \( T = 1.85, p = 0.16 \); PP group, \( T = 0.33, p = 0.76 \)).

8.6.5 Verbal protocols

The number of references to plan formulation, plan updating/monitoring and to failed
plans were counted as were the number of plan indicating behaviours. These data appear in Table 8.2. The individual breakdown of utterances appears in Appendix 5. From Table 8.2, it can be seen that subjects in the CT group made proportionally more references to plan formulation than did subjects in the PP group.

Table 8.2

<table>
<thead>
<tr>
<th>Number and category of protocol references indicating planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Total number of plan type references for group</td>
</tr>
<tr>
<td>Average number of plan type references per subject</td>
</tr>
<tr>
<td>Number of references to plans formulated %</td>
</tr>
<tr>
<td>Number of references to plans updated %</td>
</tr>
<tr>
<td>Number of references indicating failed plans %</td>
</tr>
</tbody>
</table>

8.6.6 Low Back Pain Data

Subjects' reports of their LBP were inspected. No discernible trends emerged.
8.7 Discussion

The results of this study again suggest that both relevant CT and additional physical practice benefit transfer, albeit to different extents. However, there is also some suggestion which is, broadly speaking, in line with the model's predictions that their effects may be differently mediated. To facilitate comparison between this study and Study 2, the discussion will adopt a similar format to that in Chapter 7. Thus, it will begin by considering possible reasons for, and factors which may have influenced, the specific results by considering the dependent variables. It will then discuss the relationship of the behavioural and performance findings and the more general implications of the data.

8.7.1 Specific results of study

Again, the pattern of the behavioural data indicates that subjects in the CT group demonstrated more and better planning than those in the PP group and, unexpectedly, that both groups demonstrated similarly enhanced performance.

8.7.1.1 Protocols

The methodological concerns regarding the use of retrospective protocols have previously been discussed (see section 7.8.2.1) so will not be repeated in detail here. Suffice to reiterate both the need for the development of improved methodologies to access cognitive behaviour and the importance of treating the protocol data cautiously in attempts to understand the behavioural data. Intuitively, it might have been expected that subjects in this study would be, 'more aware' of their backs and would, in general,
evidence higher levels of planning. However this was not supported and the trend in the data was not dissimilar to that found in Study 2.

**8.7.1.2 Accuracy of self-ratings**

The marked improvement in accuracy observed in the CT group was in stark contrast to the fairly constant accuracy observed in the PP group, so it was disappointing, that in neither group did the difference reach statistical significance. As the sample size was reduced by the non-compliance of several subjects who found self-reporting difficult, it seems feasible that a larger sample size may have demonstrated statistically significant changes. However, Chi and van Lehn (1991) have previously suggested that self-reporting is a skill that subjects need to learn and it may be that attention should be paid to the development of these skills in future use of this method of assessment.

Whatever phenomenon self-ratings represent, it appears to be a dimension amenable to the influence of cognitive training. Furthermore, thus far it has provided the most convincing differential between the CT and PP groups. The question raised is what does this differential constitute, in other words, What do accurate self-rated performance scores represent? The initial assumption was that a subject's rating of their own performance would provide an indication of their perceptual behaviours. If this is indeed the case then not only does relevant CT change subjects perceiving behaviours but it appears to do so in a positive way. Given that the improved accuracy is accompanied by increased planning, it seems possible that the improved perceiving behaviours may contribute to improved plan formulation as the model suggests.
However, this assumes that self-reports reflect not only subjects' perceiving behaviours, but also the latter's effectiveness in supporting planning and then executing. This may not be the case. Furthermore, it may be that self-reports embody something other than perceiving behaviours. For example, it is possible that motivational or other affective elements form part of any self-report measure.

8.7.1.3 Performance

Following intervention, the pattern of the performance scores was not markedly dissimilar to that found in Study 2, with the scores of the CT group only just failing to reach statistical significance and the PP group demonstrating significant improvement. A reasonable explanation for the improvement in performance effected by additional PP is that it resulted largely from the actual or perceived development of better physical structures to support the execution of performance. Although baseline assessment of physical structures was not made, given that experience of LBP is frequently associated with, for example, weakness of the trunk musculature (Biering-Sorensen, 1984), this seems a more tenable explanation for subjects in this study than it did for those in Study 2. However, as subjects in the PP group evidenced planning behaviours similar to those in the cognitively trained group, but relatively unchanged perceiving behaviours, these results appear to confirm the suggestion that planning may be supported partly by supporting perceiving and also by other means.

It is curious to note the presence in the CT group of one subject whose performance score not only failed to improve post-intervention but actually deteriorated slightly.
This may imply that there may be particular characteristics of a subject which render them suitable for cognitive training. It seems most likely that these might be characteristics relating to the actual or perceived pain experience but unfortunately inspection of the raw LBP data does not offer any clues to this issue. Future work might valuably seek to establish ways of assessing how individuals might be optimally matched to the training they are offered.

8.7.2 General discussion/implications

In overall terms, despite encouraging results, this study had several overarching limitations within which the general implications of the findings need to be considered. Firstly, although the trend for both of the groups was for there to be fewer plan type references than in Study 2 and a lower proportion of failed plans, given the constraints of protocol data it would seem unwise to overinterpret this. However, it is possible that subjects with an experience of LBP take more care in formulating their plans and perhaps consider the intended plan(s) with respect to their potential to damage their backs or lead to the experience of pain or discomfort. One limitation of the present study was that no assessments were made of subjects' perceptions of self-risk. Such data might provide an indication of whether or not this line of thinking is helpful.

As in Study 2, it is possible that the findings regarding performance arose from differences between the groups in terms of factors which may have altered their presensitisation to the intervention, for example, personality traits or mood at the time of being either trained or tested.
Once again the results in terms of planning and performance for the physical practice and CT groups were more similar than expected. From this study and the previous one, it appears that PP supports planning although it does not seem to do so through those perceiving behaviours captured by self-reports. Thus, in terms of the model, the prediction that relevant cognitive training would offer more support to the knowledge-of-tasks representation and to perceiving behaviours than additional physical practice did, seems to have been reasonable.

To summarise, the subjects who received relevant cognitive training demonstrated improved planning behaviours which supported better performance scores on transfer, supporting the hypothesis that relevant CT improves actual performance in people with an experience of LBP. The model's predictions that the intervention would provide a generic goal structure able to support a larger number of specific instances of patient-handling were also supported but the predicted lesser effect of additional physical practice was refuted.

Echoing the findings of Study 2, both PP and CT had a positive effect on transfer. In the CT group it seems that, in line with the model's predictions, relevant cognitive training supports enhanced perceiving behaviours which in turn are associated with better planning. It is more difficult to explain why transfer improved in the PP group. Although subjects' planning improved, this could not be attributed to a change in perceiving behaviours. One possibility is that given that the additional physical practice involved two scenarios, it provided subjects with practice in solving problems. If this
was the case then presumably physical practice schedules utilising only one scenario or utilising three would produce poorer or enhanced transfer respectively.

In relation to the model, the positive effect of additional physical practice found in both Study 2 and Study 3 may suggest that the model should be modified so that at least an indirect relationship between execution and planning is characterised. This may be achieved by allowing the executing process to write to, as well as read from, the controlling process. It might also be reasonable to suggest that reading and writing should be allowed between perception and execution. Such a direct link would be consistent with the views of proponents of non-representational approaches to motor control discussed in Chapter 7 (e.g. Kugler, 1986; Turvey, 1990). However, there is a need for future work to use more specific, controlled experimentation to manipulate different pathways in the model. Only when there is more conclusive evidence available would it be reasonable to modify the model.

8.8 Applying the model more widely

The attempt at generalisation to a subject group with an experience of LBP, who were also required to perform patient-handling tasks was the most logical progression of the research. Both the literature and the findings of Study 1 demonstrate that the operational problem for subjects with a back pain experience is certainly as, if not more, acute than for their 'normal' counterparts. However, the fact that the intervention prescribed by the model was the same as for subjects without an
experience of LBP raises several interesting issues. Firstly, is the possible implication that the model lacks appropriate sensitivity to support differential prescriptions for different situations. Yet, the results of Study 3 suggested support for the model's predictions of different mechanisms of action for additional physical practice and mental imagery. This support would seem to render criticisms regarding sensitivity rather premature.

This leaves a second implication: that the scope of training options currently conceived is limited, in other words, the value of the model is itself constrained by the lack of suitable training alternatives which can adequately map to and implement the model's prescription(s). This is, in a sense, the inverse argument to the suggestion that, whereas, in the specific case investigated the interventions tested were those prescribed by the model, alternative interventions may have supported planning leading to equivalent or better results.

However, these two perspectives are not incompatible. It is possible that along with the need to extend the scope of available training options is an indication to develop the granularity of the model such that the optimal enhancement, in any given situation, might be prescribed.

As Study 3 recruited the model in a way similar to that used in Study 2, future work might focus on the application of the model to other domains. For example, it might be applied to the training of subjects undertaking sporting tasks such as golf or tennis in
which strategic planning and control is required. If the application of the model to the
domain of sports coaching is considered it can be seen that different sorts of training
might be prescribed for different types of coaching requirements. Hence, physical
practice might be prescribed to support the low level development of the basic strokes
of say tennis or golf. In order to refine the basic strokes such that they might be used in
a game the model might prescribe other kinds of interventions to support plan-related
activities. Thus, trainees may need support for their perceiving behaviours such that
they learn to recognise critical predictive features of, for example, when a ball is going
to be out or drop short. Equally, they may require to be taught about planning, such
support perhaps being implemented via mental rehearsal.

8.9 Summary and conclusions

Study 3 has demonstrated the utility of the MMAC model in a more general sense. It
achieved this by empirical testing of the prescribed cognitive training and of additional
physical practice. The results also provide some further insight into, in particular, the
possible relationship between planning and perceiving within the model. The evidence
continues to be suggestive of transfer to the real-world but more detailed consideration
of the implications of the research is the concern of Chapter 9.
Chapter 9

ASSESSMENT OF THE RESEARCH

9.1 Chapter overview

This chapter concludes the thesis, by assessing the contribution of the work previously described, by reviewing its major strengths and weaknesses and, by considering how it could it be developed further in its attempt to meet the stated aims. The contribution to both the specific and the general problems is considered with respect to the methodological and substantive issues involved. The chapter concludes with consideration of questions raised by the work for future investigation.

9.2 Introduction

The work reported in this thesis has addressed a particular problem presented in the ineffective design of training programmes in patient-handling. The enhanced training programme offered as a solution was derived from a model for reasoning about training programme enhancements. The specific problem and the specific model developed as a solution exemplified the development of a solution to the general problem of ineffective training for physical tasks. The model constitutes the principal contribution of the research. The solution itself - the enhanced training programme - is offered as a secondary contribution. The model can also claim to have contributed to the more general problems, of providing support for reasoning about both the design of training programmes in patient-handling, and the design of training programmes for tasks with a substantial
9.3 Contribution to the solution of the specific problem

9.3.1 Scoping the problem

Chapters 1 and 2 identified firstly, training in patient-handling as a requirement for health service professionals including physiotherapists and secondly, the ineffectiveness of training programmes as reflected in their failure to reduce the incidence of LBP. It was noted that those designing training programmes were currently not supported by any explicit framework leading to the conclusion that the design of programmes was essentially ad hoc. On the basis of studies conducted either in the classroom setting (e.g. Troup and Rauhala, 1987), or else in the workplace (e.g. St Vincent and Tellier, 1989), the available evidence indicated that training in patient-handling lacked effectiveness. Although a variety of reasons for ineffectiveness have been suggested (Pheasant, 1991), they have not been clearly established nor related to the design of the training programme. Hence, in Study 1 an investigation of a specific training programme was undertaken.

Unlike previous studies (e.g. Videman et al, 1989), Study 1 assessed novices' performances in both the classroom and the workplace. In relation to existing work, the comparison of novices' workplace performances with those of experts was also novel, and provided a basis for claiming that any differences between the two groups might be amenable to improvement. Hence, any proposed enhancements to training which might be derived from the study should be practicable.
From the findings of Study 1, the ineffectiveness of training was attributed to novices' poor compliance with the taught material when they were required to transfer it to the workplace. Hence, in the example studied, it appeared that novices' performances in the workplace were significantly worse than those in the classroom. This led to the conclusion that there was a problem with the transfer of knowledge from the classroom to the workplace situation. In addition, when novices' workplace behaviours and performances were compared with those of experts, salient deficiencies in the novices' ability to formulate plans were identified. Part of the problem was attributable to there being no means to determine, prior to specification, how to design the training programme. A solution to the problem was sought which would support the design of training programmes which support the more effective transfer of knowledge.

9.3.2 Solving the specific problem - methodological contribution

9.3.2.1 Developing the model

The solution offered to the problem evidenced at King's College was a model-based approach to reasoning about the design of patient-handling training programmes. The MMAC-PH model of planning and control was developed in response to the findings of the first study. Although the implications of motor control theories to manual handling training have previously been raised, (Burgess-Limerick and Abernethy, 1993) the MMAC model provided a novel analytic way of characterising the planning deficits observed in novice physiotherapists. The model was developed by relating novices' performance deficits to their cognitive behaviours, and comparing them with the levels of performance and behaviours of experts. The model comprised two cognitive representations, namely,
knowledge-of-tasks and plans, and four cognitive processes: perceiving, planning, controlling and executing. Within the plans a set of goal structures and a library of behaviours were conceptualised. These provided a basis not only for comparing novices and experts behaviours but also for relating the deficiencies in the novices behaviours to the knowledge provided by the training programme.

9.3.2.2 Using and testing the model

The model was used to relate the information from the specification of the problem to various potential solutions. The model-based approach can be contrasted with an approach more closely related to everyday practice. It was novel in two ways. Firstly, there had previously been no generally recognised way of designing manual handling training programmes and the model attempted to relate the design of training programmes to the observed behaviours. Secondly, although biomechanical, physiological and psychophysical models of lifting exist (Ayoub, 1992), there had been no previous attempt to integrate psychological and physical discipline knowledge in order to support the specification of patient-handling training. The model attempted to bridge this gap by addressing the relationship between cognitive activities and patient-handling behaviours.

The development of the solutions suggested by the model was described in Chapter 6, and two of them were tested in the first empirical study described in Chapter 7. The conclusions stated that, under the experimental conditions, both additional physical practice, and mental imagery supported the transfer of patient-handling skills. Although the empirical findings were only partially consistent with the model's predictions,
Chapter 9: Assessment of the research

the model achieved its aim in supporting the prescription of solutions which were successful in solving the problem. Hence, given its stage of development, the model fulfilled its purpose and can claim to be at least partially effective. Nevertheless, the absence of any significant difference between the two interventions prescribed raises the question, could this absence be attributed to deficiencies in the model? In response to this, it must be borne in mind that the model did enable reasoning about enhancements to the training programme.

The model was derived from data obtained in the workplace, so, logically, the reasoning it supports concerning training enhancements apply to the workplace. Yet, the solutions suggested by the model were tested in a relatively controlled experimental situation. The latter relied on the use of simulations, in which behaviour was instantiated in order to permit assessment of performance. The majority of previous studies concerned with assessing the effectiveness of patient-handling training have used as dependent variables, indices of back pain, for example sick leave (Wood, 1987). Of the limited number of previous studies which have made assessments of subjects' compliance with the taught procedures, the simulations have taken the form of asking subjects to imagine a particular clinical situation (Videman et al, 1989). The approach taken in the present work was an advance on the latter in that at least some of the physical aspects of the workplace were simulated with reasonable fidelity. However, environmental and social factors were not simulated and this is as much a limitation of the present work as of previous work.

As an alternative, the model's predictions could have been tested using a rigorous non-
Chapter 9: Assessment of the research

simulation based experimental approach. It is feasible that this would have increased the chances of obtaining more positive experimental results. Although such an approach may have had technical appeal in terms of the iterative development and testing of the model viewed from a scientist's perspective, this must be contrasted with the practical purposes of the work presented here. The requirement was to improve an actual course. Hence it was reasonable to sacrifice some experimental rigour in order to accommodate pragmatic constraints.

One difficulty presented by simulation-based methods is that simulations are designed to reproduce only selected aspects of a worksystem and its domain (Life, 1990). Although the physical fidelity of the simulations used was assessed, performance and associated behaviours will only be accurately assessed if the fidelity of the simulation is adequate both physically and psychologically. Clearly, achievement of such fidelity is impractical, not least because of the difficulty in defining it. Hence, it is just possible that the failure to identify any significant difference between the effects of additional physical practice and cognitive training was, in part, due to difference in the relationship of the simulation to the different behaviours supported by additional physical practice and cognitive training.

Nonetheless whatever concerns surround the testing of the model, it is important to remember that not only did it succeed in supporting reasoning about ways of solving the problem, but it also introduced an enhancement to the training programme which has considerable pragmatic benefits.
Chapter 9: Assessment of the research

9.3.3 Solving the specific problem - substantive issues

The principal substantive contribution to the specific problem of the ineffective training programme at King's takes the form of the enhancement, namely, cognitive training, indicated by the model. Hence, secondary contributions of the research reported in this thesis exist in the form of the two enhanced training programmes proposed and tested in Studies 2 and 3, reported in Chapters 7 and 8 respectively. The success of these programmes validates the model but does not indicate that the programmes themselves cannot be improved. The absence of any significant differences between the two interventions partly underlines this line of argument but, equally, the failure to find significant differences may have been due to experimental weaknesses.

At face value, a significant weakness might be attributed to the relatively small sample sizes which were a consequence of the limited availability of suitable subjects. Given the variability in subjects' scores in both studies, it may be that a larger sample size would have been desirable to clarify the status of the trend observed in the data which indicated some superiority of mental imagery over physical practice for some subjects and vice versa. Distinguishing those subjects who would benefit more from cognitive training from those who would require additional physical practice would probably necessitate collection of more data concerning, for example, subjects' fitness levels or their previous experience of motor learning.

The absence of any significant difference between the effects of mental imagery and physical practice may also have reflected poor resolution in the measure used to assess
performance. In other words, the use of agreement between two independent raters' subjective judgments, which were reliable over time, was precise enough for the purposes of demonstrating the utility of the model, but too coarse to distinguish subtle changes in performance. The use of additional raters, whilst desirable, was not a practical possibility in the present research. Alternatively, it may be that the number of criteria included in the performance checklist needs to be extended if subtle changes are to be detected. The additional criteria might include, for example, assessment of the position of a subject's feet when handling a patient.

Subjects' behaviours when implementing actions in a complex environment are inherently variable. Variability exists both within an individual subject's performances as well as between subjects. Furthermore, subjective judgments of a subject's performance of a complex, dynamic task lasting anything up to ten minutes may lead to variability in assessment and this may have been a source of error, leading to a reduction in the sensitivity of the judgments. Similarly, although the behavioural differences between novices and experts were based on observed sequences of action-object interactions, they also contain elements of subjective judgment, which could have been verified by a second assessor.

Future work might valuably develop more sensitive measures, perhaps using quantitative assessments, achieved, for example, via the digitisation of markers placed on a subject's body. However, in the work presented here, such assessments would almost certainly have been more intrusive and led to some sacrifice of ecological validity. Hence, the
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decision to rely on subjective assessment was rational and reasonable. Furthermore, it may be that the complexity of patient-handling behaviours is such that identifying a methodological technique which is able to demonstrate clean differences between subjects is not possible. Whatever the balance of opinion, both the performance and behavioural measures used in this work were appropriate to its purposes and demonstrated the use of the model.

However, in the context of planning behaviours, the need for improved methods of assessment is unequivocal. The use of planning probes was a first step in this direction, yet the reliability and validity of such measures is untested. To develop this technique further, the need is for more controlled investigation of planning probes in a less complex environment. This might be achieved by, for example, assessing planning using a task in which a subject's response set to a probe is more constrained. For example, if subjects were interrupted whilst attempting a pegboard task or a board game such as chess, the number of responses would be much more limited and their quality easier to assess. Such investigation would facilitate clarification of the scope of a planning probe and might provide insight into its development, to support the exploration of plans in complex environments. This does, of course, presuppose that such exploration is feasible. It is possible that plans can only be adequately accessed in situations such as office administration (Smith et al, 1992a) in which they are more explicit.

Considerations of experimental weaknesses and the inability to clearly distinguish between the interventions should not be allowed to detract from the practical significance of the
findings. Cognitive training appears to provide a means of enhancing training programmes in a manner which is potentially more cost-effective in terms of reducing the need for both human and non-human resources. Clearly this is an important consideration in both the resource-limited circumstances of the National Health Service in the mid 1990's and also more generally. Furthermore, cognitive training is also without the risk of injury which may be associated with its physical counterpart. This is obviously especially pertinent to those with a history of previous back injury but is also relevant to the avoidance of the ironic situation which may occur when a healthy person damages their back during training.

9.3.4 Summary

To summarise, the principal contribution offered by this work is the development and use, in two situations, of a model to, firstly, characterise the problem of defective transfer of patient-handling skills, and secondly, to reason about enhancements to patient-handling training programmes for physiotherapy students. Secondary contributions are offered in the form of the two enhanced training programmes which have been proposed and tested.

9.4 Contribution to the solution of the general problem

The general aim of the work, as stated in Chapter 1, was to explore one answer to the question of how ergonomics can contribute to the design of more effective training programmes in patient-handling, such that the required physical and mental behaviours, and their relationship are supported. The specific problem investigated is part of the more
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general problem of the ineffectiveness of the design of patient-handling training programmes. This in turn is part of the larger general problem of the ineffective design of training programmes for tasks which are, at face value, predominantly physical.

One of the problems with taking a relatively broad approach is that the limitations on the investigations mean that generalisation with respect to other populations and domains is not guaranteed. In that it tackles both the construction of a new model of the activity and the application of that model, the work tries to answer all rather than part of a large question. It would have been possible to have focused in more detail on one area of the work, for example, a more complete specification of the problem perhaps improving the development of the model. However, such an approach would almost certainly have constrained the investigation of solutions prescribed by the model.

The MMAC framework had previously been used to support models of the behaviours of medical receptionists (Hill et al, 1995). However, it had not previously been operationalised in the context of people performing tasks with a predominantly physical component. Neither had it been used in a training context. Hence, the work presented here was novel on two counts in relation to its contribution to the development of the MMAC-PH model.

The paucity of previous work on model development to characterise the mental and physical behaviours of real world tasks meant that it was necessary to consider the different classes of model available, both in terms of knowledge representation and in
terms of their ability to characterise tasks which require substantial physical behaviours. The choice of the MMAC modelling framework was appropriate in that the characterisation of the problem it supported provided the reasoning which led to the prescription of effective interventions. However, it seems feasible that by extending the power of the knowledge representation some of the concerns generated by the present work might be addressed. For example, the introduction of some production rules into the knowledge representation of plans might provide a means of enhancing the sensitivity of the planning probes. This might be achieved by using the rules to set up a clear specification of a set of finite responses to a plan. This type of development might provide the basis of work aimed at distinguishing the effects of additional physical practice and cognitive training with respect to planning.

The work presented here demonstrated the value of the model in two situations. Patient-handling tasks well exemplify many tasks in which overt physical behaviour predominates, and it seems reasonable to suggest that the model may have utility with respect to other tasks. For example, in Chapter 8, generalisation of use of the model to prescribe the training interventions tested in Study 3, could have been attempted by consideration of transfer in relation to other applications, other manual handling programmes, or other classes of novice. Thus, the options for generalisation include: training subjects for other areas of non-patient manual handling, e.g. industrial lifting tasks; training subjects for different, i.e. non-manual handling tasks, e.g. sporting tasks; training subjects who differ in some way which might affect the optimal design of the training programme. In order to give the model wider applicability to people designing training courses to support other
physical tasks, it needs to be tested in further contexts. As a logical extension of the present work variation in shape and type of both human and non-human loads might be investigated, as might tasks in which two or more people are required to work as a team.

9.5 Future work

The work presented here has not only addressed patient-handling training in a new way. It has also shown how a training programme intended to support subjects' performance of predominantly physical tasks, can be considered with respect to the cognitive components, in order to reason about the effectiveness of a course. This has not yet been formalised into a method by which course designers might configure their own programmes. Hence, future work might aim to use the knowledge provided by this work, in order to develop a proceduralised method (e.g. Diaper and Johnson, 1989) which can be used by course designers. Such a method would follow and make explicit the stages adopted in the present work.

Although investigation of the prescribed solutions in a workplace situation would have been ideal, given the complexity of the task, assessing the effectiveness of the prescribed interventions, in the first instance, demanded the rigour of a relatively controlled experimental approach. However, a follow up study in the workplace would have several benefits. Firstly, it would provide an assessment of the robustness of the intervention's effect with respect to interacting physical, psychological and social features which are impractical to simulate and would also indicate salient deficiencies in the simulation.
Secondly, given that the empirical work indicated support to transfer it seems likely that, novices' workplace performances would evidence at least some improvement and would further validate the model and perhaps suggest refinements to it.

Investigating further the comparison between different forms of cognitive training would be a different kind of extension of the work presented here, since it need not relate to the development of the model. For example, variations in the length, scheduling or nature of verbal instructions might be investigated.

9.6 Evaluation of the overall contribution of the research

In conclusion, the work described in this thesis was undertaken to answer the general question posed at the beginning of Chapter 1 - Can ergonomics contribute to the design of more effective training programmes in patient-handling? In response, the use of a model-based approach has challenged the reliance on more traditional ways of considering training programmes for physical tasks. In so doing, it has provided a solution to the problem which would not have emerged from a more conventional approach. It has not only demonstrated the impact of, and relationship between, cognitive failure and a real time physical activity, but has also provided a means of reasoning about ways of supporting such an activity.

The work described here was, then, ambitious and its contribution should be evaluated in that light. Although cognitive training has not previously been used in the context of
patient-handling training programmes, no claim is made that either of the enhancements per se are novel or definitive. Rather, the novelty lies in the way that the particular contribution explored is characterised: by its illustration of the use of discipline knowledge from physical and psychological disciplines; by its commitment to the ergonomic activities of acquiring and applying knowledge about tasks; and by the attempt to link these activities in order to support reasoning about the enhanced design of training programmes.

9.7 Summary and conclusions

In summary then, the research described here is offered as a demonstration of the utility of a model-based approach to reasoning about manual handling training design, and to identifying enhancements which merit further consideration. It is hoped that this demonstration will be useful to those whose aim it is to design training programmes which support trainee behaviours compatible with the programmes' ultimate goals of reducing the incidence of low back pain.
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Appendix 1

OBSERVATIONAL STUDY 1: MISCELLANEOUS DOCUMENTS

1.1 Training Programme
1.2 Structured Interview Questions
1.3 Performance checklist
1.1 Training Programme

The content of the training programme was as follows:

LECTURE BASED KNOWLEDGE (mainly declarative knowledge; small amount of procedural knowledge)
The lecture knowledge included reference to: causes of back pain; mechanics of the spine; Health and safety law; Preparation for lifting; posture of handler/patient; patient-handling skills; assessment of patient, environment; assistive equipment; teamwork and commands; patient cooperation.

The lecture principles were embodied in the mnemonic BACK FIRST:

**B**  Be confident  seek assistance if necessary

**A**  Assess the situation  clear obstacles
        can the patient help?
        height of bed/chair?
        do the brakes work?

**C**  Check your clothing  remove badges, scissors
        which could damage the patient or you

**K**  Keep you feet apart  walking stance
        maintaining balance

**F**  Flex knees  use your strong leg muscles

**I**  Imprison object  get close to the patient
        lessen the exertion - less likely to drop

**R**  Raise your head  ensure correct posture

**S**  Straighten your back  protect your spine, do not twist

**T**  Time  communication


Appendix 1

DEMONSTRATION-BASED KNOWLEDGE (mainly procedural knowledge)
This included: posture of handler; patient-handling skills; manual holds; advantages and disadvantages of different types of lift

PRACTICE-BASED KNOWLEDGE (procedural and declarative knowledge)
This included: patient-handling skills; posture of handler; manual holds; turning and positioning patients; assisting movement

INSTRUCTIONAL METHODS
The training programme involved lectures, and two types of practical teaching. Part of the practical teaching entails the trainees watching demonstrations (skilled, i.e. of the trainer and unskilled, i.e. of their colleagues when they were require to provide feedback) of handling manoeuvres and the other part requires them to physically practice the demonstrated manoeuvres.

TIMING
The temporal organisation of the training programme and its relationship to the classroom and workplace assessments was as follows:

<table>
<thead>
<tr>
<th>YEAR 1</th>
<th>Term 2</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term 1</td>
<td>Term 2</td>
<td>Term 2</td>
<td>Term 2</td>
</tr>
<tr>
<td>1 x 1 hr L + video</td>
<td>3 x 1 hr D/P</td>
<td>1 x 3 hr D/P assignment</td>
<td>Clinical practice 6 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CR assessment</td>
<td>Clinical practice 8 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ WP assessment</td>
</tr>
</tbody>
</table>

Key: L = lecture knowledge; D/P = demonstration and practice; CR = classroom; WP = workplace

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1.2 Structured Interview Questions

The full questionnaire which formed the basis of the semistructured interviews was as follows:

1. Was the material delivered in the lecture:

5 - at a level far too high for you to understand
4 - at a level a bit beyond your understanding
3 - at about the right level for you to understand
2 - at too trivial a level relative to your understanding
1 - at far too trivial a level relative to your understanding

2. Did the lecturer emphasise the main points:

5 - very often
4 - often
3 - occasionally
2 - not often
1 - hardly at all

3. Did the lecturer:

5 - use multiple well chosen highly relevant examples
4 - use sufficient, fairly relevant examples
3 - use some examples but too few and insufficiently relevant
2 - use hardly any relevant examples
1 - use no examples at all
Appendix 1

4. Do you find the lecture material

5 - extremely easy to remember
4 - fairly easy to remember
3 - easy to remember
2 - fairly hard to remember
1 - extremely hard to remember

5. Did you find the demonstrations:

5 - extremely clear and easy to follow
4 - fairly clear and easy to follow
3 - clear
2 - unclear in parts somewhat hard to follow
1 - extremely confusing and difficult to follow

6. Do you think you were given sufficient opportunity to practice the techniques demonstrated:

5 - far too much time
4 - too much time
3 - about the right amount of time
2 - too little time
1 - far too little time

7. In relation to the quality of feedback you received concerning your performance was it:

5 - extremely good feedback
4 - fairly good feedback
3 - good feedback
2 - fairly poor feedback
1 - extremely poor
8. Do you find the information conveyed in the practical parts:

5  - extremely easy to remember
4  - fairly easy to remember
3  - easy to remember
2  - fairly hard to remember
1  - extremely hard to remember

9. Did the practicals enable you to acquire:

5  - a very good understanding of how to lift/handle
4  - a good understanding of how to lift/handle
3  - an adequate understanding of how to lift/handle
2  - a poor understanding of how to lift/handle
1  - a very poor understanding of how to lift/handle

If poor I think this was because of
a) poor quality of examples
b) me not paying attention
c) other ........

10. When you were lifting and handling in this situation and trying to carry out the procedures you were taught, in relationship to the mental effort involved did it seem:

5  - effortless
4  - a fairly small effort
3  - neither a large nor small effort
2  - a fairly large effort to do so
1  - a very large effort

If a large effort, I think this is because
Appendix 1

a) I feel depressed
b) my mind was on other things
c) other ..........

11. When you were lifting and handling in this situation and trying to carry out the procedures you were taught, in relationship to the physical effort involved did it seem:

5  - effortless
4  - a fairly small effort
3  - neither a large nor small effort
2  - a fairly large effort to do so
1  - an extremely large effort

12. What level of risk do you think you were at in the lift you have just carried out:

5  - high risk of injury, pain discomfort
4  - fairly high risk
3  - moderate risk of injury etc
2  - slight risk
1  - no real risk

What are the likely consequences of failing to lift/handle 'correctly'?

13. Do you think that you applied the procedures taught:

5  - correctly
4  - more or less correctly
3  - not sure
2  - not quite correctly
1  - completely incorrectly
Appendix 1

14. Having just completed a lifting/handling activity did you feel that the physical environment:

5  - made it very easy for you to lift in the way you preferred
4  - made it easy for you to lift in the way you preferred
3  - had no effect on the way you lifted
2  - made it difficult for you to lift in the way you would have chosen
1  - prevented you from lifting in the way you would have preferred

15. Do you think your ability to lift and handle in the way you were taught has:

5  - improved markedly since you've been in the workplace
4  - improved a little bit
3  - not changed
2  - has deteriorated a little bit
1  - has got markedly worse

16. When you were assessed in the classroom did you feel:

5  - extremely motivated to do well and achieve a high score
4  - fairly motivated to do well and achieve a high score
3  - neither particularly motivated not demotivated
2  - fairly unmotivated the assessment seemed pointless
1  - extremely unmotivated not really bothered about the score you achieved

General Questions
How could the lectures have been improved?

How could the demonstrations have been improved?

Do you think training in lifting/handling techniques is an important part of the curriculum. Why?

How many times a day do you have to lift/handle

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1.3 Performance Checklist

1.3.1 Criteria Which Form the Basis of the Checklist

The performance checklist was based on assessment of five criteria as follows:

Criterion 1: Did the subject get as close to the load as possible?
In assessing this criterion, the rater was asked to judge the extent to which the load was as close to the body as possible. The rater was asked to consider whether the handler could have moved any closer to the patient or got the patient to move closer to him/her, and whether (s)he was as close as possible, given the physical circumstances of the workplace and the requirements of the task.

Criterion 2: Did the subject keep the back as straight as possible?
The rater was asked to judge the extent to which the trunk was maintained as close to the vertical position as possible. If the back was not as straight as possible, could the lifter have moved closer or bent the knees more in order to facilitate it, given the physical circumstances of the workplace and the requirements of the task.

Criterion 3: Did the subject lift/handle as smoothly as possible?
The rater was asked to judge the extent to which smooth as contrasted with jerky movement was executed during the handling procedure, and the extent to which a constant acceleration was produced throughout the movement. If there were jerks in the movement could these have been avoided, or were they out of the lifter's control, given the physical circumstances of the workplace and the requirements of the task.

Criterion 4: Did the subject avoid twisting unnecessarily as far as possible?
The rater was asked to judge whether the lifter twisted laterally during the manoeuvre, and whether this could have been avoided if the lifter had taken an extra step, and given the physical circumstances of the workplace, and the requirements of the task.

Criterion 5: Did the subject ensure adequate grip as far as possible?
The rater was asked to judge whether the lifter grasped the patient as fully as possible (given the physical circumstances) using one of the recognised hand holds (representing a power rip), or whether (s)he relied on using the distal parts of the fingers, i.e. a pinch
grip.

For criteria 1, 2 and 3, the rating was performed using the following scale:

- 3 - complied extremely well, almost perfectly with the criterion
- 2 - complied reasonably well but not perfectly with the criterion
- 1 - complied reasonably poorly and very imperfectly with the criterion
- 0 - complied extremely poorly and hardly at all with the criterion

For criteria 4, and 5, rating was performed using reference to time, as it seemed likely that qualitative judgments of these criteria would be more difficult to make. The following scale was used:

- 3 - complied with the criterion more or less all the time (more than three-quarters of the time)
- 2 - complied with the criterion most of the time (between half and three-quarters of the time)
- 1 - complied with the criterion some of the time (less than half of the time)
- 0 - negligible compliance with the criterion (hardly any of the time)
Appendix 1

1.3.2 Performance Checklist

Did the subject get as close to the load as possible?
_Could the load/patient have been moved closer before the start of the lift e.g. could the patient have been moved to the edge of the bed/chair? Could the subject have moved closer to the load?
_Was there a more appropriate type of lift?
  3 - complied extremely well, almost perfectly
  2 - complied reasonably well but not perfectly
  1 - complied reasonably poorly and very imperfectly
  0 - complied extremely poorly and hardly at all

Did the subject keep the back as straight as possible
_Could the knees have been bent more to allow the trunk to be more erect? Was there a more appropriate type of lift? Could the workspace have been adjusted e.g. bed height?
  3 - complied extremely well, almost perfectly
  2 - complied reasonably well but not perfectly
  1 - complied reasonably poorly and very imperfectly
  0 - complied extremely poorly and hardly at all

Did the subject Lift/handle smoothly
_Was the manoeuvre smooth and free from jerks particularly at the beginning?
  3 - complied extremely well, almost perfectly
  2 - complied reasonably well but not perfectly
  1 - complied reasonably poorly and very imperfectly
  0 - complied extremely poorly and hardly at all

Did the subject avoid twisting unnecessarily
_Could twisting have been avoided by taking an extra step? Was there a more appropriate type of lift? Could the workspace have been adjusted e.g. locker position
  3 - complied with the criterion more or less all of the time (> than 75% of the time)
  2 - complied with the criterion most of the time (between half and three-quarters of the time)
  1 - complied with the criterion some of the time (less than half of the time)
  0 - negligible compliance with the criterion

Did the subject ensure adequate grip
_i.e. were the hands placed using one of the taught grips to ensure power and avoiding gripping using only the distal parts of the fingers
  3 - complied with the criterion more or less all of the time (> than 75% of the time)
  2 - complied with the criterion most of the time (between half and three-quarters of the time)
  1 - complied with the criterion some of the time (less than half of the time)
  0 - negligible compliance with the criterion
Appendix 2

STUDY 1: OBSERVATIONAL STUDY - DATA

Table 2.1: Association between performance scores for classroom and workplace performances obtained between rater 1 and 2 and from each rater on two separate occasions

Table 2.2: The performance score for each novice subject in the classroom and in the workplace

Table 2.3: Experts' performance scores

Table 2.4: Summarised statistical analysis based on each rater's judgments

Table 2.5: Breakdown of novices' classroom performance scores

Table 2.6: Breakdown of novices' workplace performance scores

Table 2.7: Breakdown of experts' workplace performance scores

Table 2.8: Frequency of novices' and experts' workplace behaviours

Section 2.9 contains the breakdown of responses made to the questionnaire. Also included are sample comments made by subjects.
Table 2.1

Association between overall performance scores for classroom and workplace performances obtained between rater 1 and 2 and from each rater on two separate occasions

<table>
<thead>
<tr>
<th>Judgments</th>
<th>r</th>
<th>Intra-class correlation coefficient</th>
</tr>
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<tbody>
<tr>
<td>Rater $1_{occ1}$ vs Rater $1_{occ2}$</td>
<td>0.928</td>
<td>0.926 **</td>
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<tr>
<td>Rater $1_{occ1}$ vs Rater $2_{occ1}$</td>
<td>0.878</td>
<td>0.855 **</td>
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<tr>
<td>Rater $2_{occ1}$ vs Rater $2_{occ2}$</td>
<td>0.866</td>
<td>0.859 **</td>
</tr>
</tbody>
</table>

Key:

$occ1$ - judgments made on first rating occasion

$occ2$ - judgments made on second rating occasion

** $p < 0.01$
Table 2.2

Novices' performance scores in classroom (CR) and workplace (WP)

<table>
<thead>
<tr>
<th>Subject</th>
<th>CR rater ( <em>{1</em>{\text{occ1}}} )</th>
<th>CR rater ( <em>{2</em>{\text{occ1}}} )</th>
<th>CR rater ( <em>{1</em>{\text{occ2}}} )</th>
<th>CR rater ( <em>{2</em>{\text{occ2}}} )</th>
<th>WP rater ( <em>{1</em>{\text{occ1}}} )</th>
<th>WP rater ( <em>{2</em>{\text{occ1}}} )</th>
<th>WP rater ( <em>{1</em>{\text{occ2}}} )</th>
<th>WP rater ( <em>{2</em>{\text{occ2}}} )</th>
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<td>1.33</td>
<td>3.16</td>
<td>3.41</td>
<td>2.72</td>
<td>3.7</td>
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</tbody>
</table>

Key: WP = workplace  
CR = classroom  
\( _{1_{\text{occ}}} = \) first rating occasion;  
\( _{2_{\text{occ}}} = \) second rating occasion
### Appendix 2

Table 2.3

**Experts' performance scores**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Expert rater 1&lt;br&gt;$r_1$</th>
<th>Expert rater 1&lt;br&gt;$r_2$</th>
<th>Expert rater 2&lt;br&gt;$r_1$</th>
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<td>SD</td>
<td>1.87</td>
<td>1.9</td>
<td>1.51</td>
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</table>

Table 2.4

**Statistical analyses based on rater 1 and rater 2's judgments**

<table>
<thead>
<tr>
<th>Statistical comparison</th>
<th>Rater 1 T value</th>
<th>p value</th>
<th>Rater 2 T value</th>
<th>p value</th>
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</thead>
<tbody>
<tr>
<td>Novices' classroom performance vs novices' workplace</td>
<td>4.87</td>
<td>0.0007</td>
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<td>0.024</td>
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<td>Novices' workplace performance vs experts' workplace performance</td>
<td>4.43</td>
<td>0.0004</td>
<td>5.04</td>
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</table>

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Appendix 2

Table 2.5

Breakdown of novices' classroom performance scores into individual performance criteria

<table>
<thead>
<tr>
<th>Sub</th>
<th>rater</th>
<th>close</th>
<th>erect</th>
<th>smoo</th>
<th>twist</th>
<th>grip</th>
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Key:

LK = lecture knowledge score, (using a 1-5 scale) i.e. score awarded to subject in response to questions asked about patient-handling where 5 = far exceeds requirements and 1 = far below requirements.

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Table 2.6
Breakdown of novices' workplace performance scores

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Appendix 2

296
### Table 2.7

Breakdown of experts' workplace performance scores

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- R1 = rater 1; R2 = rater 2;
- occ₁ = first rating occasion; occ₂ = second rating occasion

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</table>
Table 2.8

Frequency of Workplace Behaviours of Novices and Experts in Study 1

| PRESENCE OF BEHAVIOURS | Novices | | | Experts | | |
|------------------------|---------|---------|---------|---------|---------|
|                        | Yes | No | n/a or u/c | Yes | No | n/a or u/c |
| **B1** PREPARATORY BEHAVIOURS Talk to/listen to patient | 11 | 0 | 0 | 11 | 0 | 0 |
| **B2** Assess clinical situation, e.g. level of pain, ability to cooperate (evidenced by questions asked/observation of any attachments) | 8 | 0 | 3 | 11 | 0 | 0 |
| **B3** Read patients notes/charts or treatment plan | 6 | 5 | 0 | 7 | 11 | 4 |
| **B4** Explain to patient by breaking whole task into sub-sections and explain task to patient | 1 | 7 | 3 | 6 | 3 | 2 |
| **B5** Clear workspace - move only relevant objects cluttering space, e.g. locker, stools | 2 | 6 | 3 | 9 | 2 | 0 |
| **B6** Prepare patient, e.g. put on slippers, tie dressing gown | 11 | 0 | 0 | 11 | 0 | 0 |
| **B7** Position or check position of wheelchair or chair patient moving to or from | 7 | 2 | 2 | 10 | 0 | 1 |
| **B8** Position or adjust bed | 3 | 6 | 2 | 10 | 1 | 0 |
| **B9** Remove arms and/or footplates from wheelchair, undo wheelchair restraining straps | 7 | 1 | 3 | 11 | 0 | 0 |
| **B10** Apply brakes to wheelchair and/or get assistant to stabilise | 5 | 3 | 3 | 11 | 0 | 0 |
| **B11** Arrange pillow on bed | 2 | 5 | 3 | 11 | 0 | 0 |
### Appendix 2

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Kev:</th>
<th>n/a</th>
<th>u/c</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>B12</td>
<td>Position patient's hands or instruct patient where to place hands</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>B13</td>
<td>Position patient's feet or instruct patient where to place feet</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>11</td>
<td>0</td>
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<tr>
<td>B14</td>
<td>Check/ensure freedom of encumbrances to patient's movement, e.g. tight clothing, orthoses, catheters</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>7</td>
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<tr>
<td>B15</td>
<td><strong>LIFTING BEHAVIOURS</strong>&lt;br&gt;Move close to the patient</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>0</td>
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<tr>
<td>B16</td>
<td>Move patient to edge of bed/chair</td>
<td>4</td>
<td>5</td>
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<td>1</td>
</tr>
<tr>
<td>B17</td>
<td>Position arms to grip/support patient</td>
<td>11</td>
<td>0</td>
<td>0</td>
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<tr>
<td>B18</td>
<td>Instruct patient during manoeuvre</td>
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<tr>
<td>B19</td>
<td>Position own body</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>0</td>
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<td>B20</td>
<td>Move patient</td>
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<tr>
<td>B21</td>
<td>Enquire about/check patient's state</td>
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<td>5</td>
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<tr>
<td>B22</td>
<td>Respond to unpredictable event which impedes patient during movement, e.g. difficulty with splint, patient becomes unsteady, nervous</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>5</td>
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<td>B23</td>
<td><strong>POST LIFTING BEHAVIOIRS</strong>&lt;br&gt;Enquire about/check patients state</td>
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<td>2</td>
<td>11</td>
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<tr>
<td>B24</td>
<td>Rearrange patient's position in bed or chair</td>
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<tr>
<td>B25</td>
<td>Rearrange workspace, i.e. reposition locker, patient's table, footstool</td>
<td>4</td>
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**Key:** n/a = not applicable to task; u/c = unclear whether behaviour occurred
### Appendix 2

#### 2.9 Interview-Based Responses to Questionnaire

**Key:** NOR = number of respondents

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<tr>
<th>Question 1</th>
<th>Was the material delivered in the lecture:</th>
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<tbody>
<tr>
<td></td>
<td>at a level far too high for you to understand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>at a level a bit beyond your understanding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>at about the right level for you to understand</td>
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<tr>
<td></td>
<td>at too trivial a level relative to your understanding</td>
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<td>at far too trivial a level relative to your understanding</td>
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<th>Did the lecturer emphasise the main points</th>
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<td>very often</td>
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<td></td>
<td>sometimes</td>
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<td>not often</td>
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<tr>
<td></td>
<td>hardly at all</td>
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<th>Did the lecturer</th>
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<td>use multiple, well chosen, highly relevant examples</td>
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<td>use sufficient, fairly relevant examples</td>
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<td></td>
<td>use some examples but too few and/or insufficiently</td>
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<tr>
<td></td>
<td>use hardly any relevant examples</td>
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<td></td>
<td>use no examples at all</td>
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<th>In the workplace do you find the lecture material</th>
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<td></td>
<td>extremely easy to remember</td>
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<td></td>
<td>fairly easy to remember</td>
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<tr>
<td></td>
<td>easy to remember</td>
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<tr>
<td></td>
<td>fairly hard to remember</td>
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<tr>
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<td>Did you find the demonstrations</td>
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<td>extremely clear and easy to follow</td>
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<td>fairly clear and easy to follow</td>
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<td>clear</td>
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<td>unclear in parts and somewhat hard to follow</td>
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<td>extremely unclear and difficult to follow</td>
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<td>In terms of the amount of time you were given to practice the techniques demonstrated</td>
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<td>far too much</td>
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<td>about the right amount</td>
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<td>too little</td>
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<td>far too little</td>
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<td>In relation to the quality of feedback you received concerning your performance, was it</td>
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<td>extremely good</td>
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<td>fairly good</td>
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<td>extremely poor</td>
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<td>Do you find the information conveyed in the practical parts of the training:</td>
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<td>extremely easy to remember</td>
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<td>fairly easy to remember</td>
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<tr>
<td>easy to remember</td>
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<tr>
<td>fairly hard to remember</td>
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<tr>
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### Appendix 2

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<th>Did the practical enable you to acquire:</th>
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<tr>
<td>1</td>
<td>a very good understanding of how to lift/handle</td>
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<td>a good understanding of how to lift/handle</td>
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<td>5</td>
<td>an adequate understanding of how to lift/handle</td>
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<td>a poor understanding of how to lift/handle</td>
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<td>a very poor understanding of how to lift/handle</td>
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<th>Question 10</th>
<th>When you were lifting and handling (related to task just performed), did the mental effort seem:</th>
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<td>1</td>
<td>effortless</td>
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<tr>
<td>1</td>
<td>a fairly small effort</td>
</tr>
<tr>
<td>5</td>
<td>neither a large nor small effort</td>
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<tr>
<td>3</td>
<td>a fairly large effort</td>
</tr>
<tr>
<td>2</td>
<td>an extremely large effort</td>
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<th>Question 11</th>
<th>When you were lifting and handling (related to task just performed), did the physical effort seem:</th>
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<td>7</td>
<td>effortless</td>
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<td>4</td>
<td>a fairly small effort</td>
</tr>
<tr>
<td>4</td>
<td>neither a small nor large effort</td>
</tr>
<tr>
<td>4</td>
<td>a fairly large effort</td>
</tr>
<tr>
<td></td>
<td>an extremely large effort</td>
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<th>Question 12</th>
<th>What level of risk of injury do you think you were at in the handling manoeuvre you have just performed</th>
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<td>2</td>
<td>very high risk of injury, pain or discomfort</td>
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<td>4</td>
<td>fairly high risk</td>
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<td>4</td>
<td>moderate risk</td>
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<tr>
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<td>fairly low risk</td>
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<tr>
<td></td>
<td>very low risk</td>
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303
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<tr>
<th>Question 13</th>
<th>Do you think you applied the taught procedures</th>
<th>NOR</th>
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<tr>
<td>correctly</td>
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<td>more or less correctly</td>
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<td>not sure</td>
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<td>not quite correctly</td>
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<td>completely incorrectly</td>
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<th>Question 14</th>
<th>Having just completed a handling activity did you feel that the physical environment:</th>
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<td>made it very easy for you to lift in the way you preferred</td>
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<tr>
<td>made it easy to lift in the way you preferred</td>
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</tr>
<tr>
<td>had no effect on the way you lifted</td>
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</tr>
<tr>
<td>made it difficult for you to lift in the way you preferred</td>
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<tr>
<td>made it very difficult to lift in the way you preferred</td>
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<th>Question 15</th>
<th>Do you think your ability to lift and handle in the way you were taught has</th>
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<td>improved markedly since being in the workplace</td>
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<td>improved a little bit</td>
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<td>not changed</td>
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<tr>
<td>has deteriorated a little bit</td>
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<td></td>
</tr>
<tr>
<td>has deteriorated markedly</td>
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<th>Question 16</th>
<th>When you were assessed in the classroom were you</th>
<th>NOR</th>
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<tr>
<td>extremely motivated to do well and achieve a high score</td>
<td>2</td>
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</tr>
<tr>
<td>fairly motivated to do well and achieve a high score</td>
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<tr>
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<tr>
<td>fairly demotivated, the assessment seemed pointless</td>
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</tr>
<tr>
<td>extremely demotivated, not really bothered about the score you achieved</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.9.2  Novices' comments

Subjects' comments were scrutinised and the following were identified as representing recurrent views:

Comments relating to training programme - Questions 1-11

'I don't think the lectures were principled enough .... not enough on what to pick up on'

'found it difficult to go from lifting other students to handling patients who are heavier and don't do what you want them to do'

'didn't realise how difficult it would be with patients - we should be made more aware of that'

'in the classroom the models know what is meant by 'push through your legs' but the public don't'

'it's (remembering the practical instruction) usually OK before the lift's in progress but once you get going I'm more focused on getting the patient through safely and I forget about what I'm actually doing'

'it's (remembering what to do) harder to remember than the theoretical side because every patient is different and you have to adjust'

'the practical classes needed to be smaller with more supervisors'

'it (the training) doesn't fit with patients'

'think the training should stress what the clinical environment's really likely to be like and not just the perfect adaptations'

General Comments - Questions 12-16

'I think I concentrated more cos of the filming'
'think if I'd had a better picture in my mind of what hemis (stroke patients) would be like I would lift them better - think I just didn't think enough about it beforehand'

'should have removed my badge/watch'

'the brakes sticking out of the bed were a real pain and the big old wheels on the chair stopped my proximity to the bed'

'think I've got more confident but not sure if I've actually changed how I lift'

'in some ways my understanding was good... I did know what to do but I hadn't thought enough about planning it especially as she wasn't able to help'.

'that porter's chair was horrendous!' 

'your head's so full of things I want to do the last thing on my mind is where my feet are or if my back's flexed'

'it's all quite a difficult manoeuvre you have to think about 101 things at the same time'

'you're more concerned about the patient, getting them to trust you... and then if you do think about your back it's usually too late'

'tend to remember isolated principles because there's so much to think about'

'when patients are full of drips and lines .. thinking of other things goes lower on the list of priorities until you forget altogether'

'slippery floors are a real problem'

'I got caught between him and the frame a couple of times but it was a compromise
between being close enough for the patient to reach but too close to get trapped'

'it's hard to get the clinical supervisors to go over the techniques so you just sort of muddle along'

'having long legs makes getting down hard - wish you could raise the wheelchair'
Appendix 3

STUDIES 2 AND 3: MISCELLANEOUS DOCUMENTS

3.1 Plan categories
3.2 List of questions to assess planning
3.3 Probe scale
3.4 Instructions to subjects
3.5 Details of simulations
3.6 Movement Imagery Questionnaire
3.1 Plan Categories

The following are examples of utterances in each category.

1. Plan formulation:
Comments similar to any of the following were taken as an indication of planning as well as any direct references to plans:
   'I was going to
   'I intended to
   'I did this because.....I thought
   'I wanted to
   'I thought that
   'I checked .... (weight of patient/height of bed)
   'I needed
   'If I did x then

2. Plan updating:
   'I was going to but
   'I thought that if I did x then but
   'I began to ...then
   'I realised that
   'It was only when x (happened) that

3. Plan failure:
Failure to plan was indicated by an absence of comments in 1. and 2. However, if planning comments were made those below indicated the existence of a poor plan:
   'I didn't realise that
   'I forgot
   'I slipped
   'I was surprised
   'I found that I couldn't
3.2 Questionnaire

a. Did you anticipate any difficulties in executing the task?
   - providing general evidence of some type of plan

b. Did you think this was a task requiring a lot of effort? (where effort is assumed to be an indicator of attentional demand)
   - providing general evidence of some type of plan (as the structures supporting the plan are partially attentional ones)

c. Did you think in advance what you were going to do from beginning to end at the start of the task?
   - providing evidence of plan formulation - existence of goal stack

d. Did this task turn out to be more or less difficult than you had expected?
   - providing evidence of poor quality plan

e. Did you think in advance about any part of the task
   - providing evidence of partial plan via partial goal stack
3.3 Scale to Assess Probe Responses

4 Response was safe, unhesitating and paid attention to patient's comfort

3 Response was safe, and/or slightly hesitant and/or disregarding of patient's comfort

2 Response was safe, and/or very hesitant and/or disregarding of patient's comfort

1 Response was unsafe, and/or very hesitant and/or paid little attention to patient's comfort

3.4 Instructions to Subjects

3.4.1 Instructions for CT\textsubscript{red} Group

1st Scenario

A 15 stone lady had major abdominal surgery several weeks ago and has made a slow post-operative recovery. She now has little and well controlled pain.

Close your eyes and imagine yourself in the following situation.

'You are going to use a shoulder lift to move a 15 stone female patient along the bed. She has a drip in her right arm. Imagine yourself facing this situation. Plan what you are going to do in order to move her up the bed, taking care to think through from the
Appendix 3

beginning of the manoeuvre to the end. Make sure that her drip and her drain are not going to hamper her movement or yours once you have started. Imagine yourself positioning your own body so that you can begin to move her. Think of the position your body is in and what it feels like. Explain to her what you are going to do and what you want her to do to help. Position your shoulder in her axilla. Imagine yourself as close to the bed as you can get, now count 1, 2, 3 and move her. Imagine yourself moving as smoothly as possible, think what the movement feels like, all the time keep yourself in a good position.'

2nd scenario

A 55 year old lady has had a Total hip replacement. She has had appropriate analgesia. You are going to help her get out of bed for the first time. She is lying supine has a drain in and an abduction pillow in situ. Close your eyes and imagine yourself in the following situation.

'The patient is lying in the bed. Plan what you are going to do taking care to think through from the beginning of the manoeuvre to the end. Remove the abduction wedge. Get as close to the bed as possible and support the patient's leg. Imagine the position your body is in and what that feels like. Help the patient move her right leg to the edge of the bed, taking care to keep it in an abducted position. Imagine yourself keeping your own back as straight and untwisted as possible. Imagine what your back feels like. Help the patient to sit up and swing her legs over the edge of the bed. Imagine yourself keeping the limb supported whilst keeping your own back as straight as possible. Imagine yourself moving as
smoothly as possible, all the time keeping yourself in a good position.'

3.4.2 Instructions for Control Group

You are sitting in a lecture concerning patients who have undergone surgical operations. Imagine yourself sitting on a lecture bench hearing about patients who have undergone abdominal surgery. The lecturer is describing the site of the abdominal incision, the likely position of the patient and of the drips and drains in situ post-operatively. He is explaining that the patient will be given analgesia and encouraged to cough to prevent chest complications. Now the lecturer is describing a patient who has undergone a Total hip replacement. She has an incision over her greater trochanter. Imagine her position in bed with an abduction wedge in situ. The lecturer is describing the likely position of drips and drains.

3.4.3 Instructions for Physical Practice Group

Physical practice intervention

Subjects in this group practised the handling manoeuvres which formed the basis of the imagery intervention scenarios, but they were not given clinical details in order to discourage them from forming images.

'You have got 20 minutes to practice 2 manoeuvres. I want you to perform 3 repetitions of each manoeuvre in turn and then repeat it so that you have done 6 repeats of each task in total. Firstly,
practice performing a shoulder lift on your colleague. Perform 3 repetitions of this manoeuvre. Secondly, practice assisting your colleague to get out of bed for the first time following a few days of bed rest. Perform 3 repetitions of this manoeuvre. Then start again with the shoulder lift. Rest whenever you feel tired but try and complete all 12 manoeuvres in the 20 minutes'

3.5 Details of simulations

The criteria for the selection of the tasks to be used in the pre and post-intervention simulations were derived from the findings of Study 1 and were as follows:

a) tasks which were commonly performed
b) tasks in which compliance with taught procedures was poor
c) tasks which could be simulated with reasonable physical fidelity, in that the layout of obstacles was representative of what might be found in a clinical environment. No attempt was made to simulate environmental or social aspects of the workplace.

Pre-Intervention Simulation

The pre-intervention simulation required subjects to assist a 'model' patient, with a drip and catheter attached, moving from sitting in a low chair, to standing, using a waist hold. The fidelity of the simulation was assessed and improved by comparison with observations made in the workplace and the video data obtained in the first study. A model patient sat in a low, deep armchair. The armchair was positioned in front of a hospital locker and adjacent to a bed. Slightly in front of the seated patient was a small wheeled table. The patient had a drip attached to the right arm, the attachment being concealed by the patient's nightwear. Attached to the patient's pubis was a catheter tube leading to a catheter bag which was half full of urine coloured fluid and rested on the left hand side of the chair.

Post-Intervention Simulation

A model patient lay in an adjustable height bed. The bed was operated via an electronic control but was not plugged in. The head end of the bed was able to be raised. The patient had a wound drain attached to the skin overlying the greater trochanter. An armchair was positioned to the side of the bed.
3.6 Movement Imagery Questionnaire (Hall and Pongrac, 1983)

The Movement Imagery Questionnaire (MIQ) is designed to measure individual differences in visual and kinaesthetic imagery of movements. It has been found to possess a high reliability visual 0.828; kinaesthetic 0.834) when administered separately to individuals in a quiet room free from distractions.

**SCORING:** The questionnaire contains two subscales. To obtain the visual imagery score sum the ratings given to the following items: 2, 4, 6, 8, 9, 10, 12, 14, 16. The minimum score that can be achieved is a 9 (high imager) and the maximum score possible is a 63.

**EQUIPMENT:** The only equipment necessary to administer the MIQ is a pencil and an exercise (floor) mat.
Appendix 3

INSTRUCTIONS

This questionnaire concerns two ways of mentally performing movements, which are used by some people more than others, and are more applicable to some types of movements than others. The first is the formation of a mental (visual) image or picture of a movement in your mind. The second is attempting to feel what performing a movement is like without actually doing the movement. You are requested to do both of these mental tasks for a variety of movements in this questionnaire, and then rate how easy/difficult you found the tasks to be. The ratings that you give are not designed to assess the goodness or badness of the way you perform these mental tasks. They are attempts to discover the capacity individuals show for performing these tasks for different movements. There are no right or wrong ratings or some ratings that are better than others.

Each of the following statements describe a particular action or movement. Read each statement carefully and then actually perform the movement as described. Only perform the movement a single time. Return to the starting position for the movement just as if you were going to perform the action a second time. Then depending on which of the following you are asked to do, either 1) form as clear and vivid a mental image as possible of the movement just performed, or 2) attempt to positively feel yourself making the movement just performed without actually doing it.

After you have completed the mental task required, rate the ease/difficulty with which you were able to do the task. Take your rating from the following scale. Be as accurate as possible and take as long as you feel necessary to arrive at the proper rating for each movement. You may choose the same rating for any number of movements "imaged" or "felt" and it is not necessary to utilise the entire length of the scale.

RATING SCALES

Visual imagery Scale

1  2  3  4  5  6  7
Very Easy Easy to Somewhat Neutral Somewhat Hard to Very Hard to Picture Picture Easy to Picture Hard to Picture Picture

Kinaesthetic Imagery Scale

1  2  3  4  5  6  7
Very Easy Easy to Somewhat Neutral Somewhat Hard to Very Hard to Feel Feel Easy to Feel not Hard to Feel Feel
1. **STARTING POSITION:** Make a fist with your dominant hand (the hand you write with) and then place this hand on the same shoulder (e.g., right hand on right shoulder) such that your elbow is pointing directly in front of you.

**ACTION:** Extend your elbow so that your hand leaves your shoulder and is straight in front of you parallel to the floor. Keep your hand in a fist. Make this movement slowly.

**MENTAL TASK:** Assume the starting position (exactly as described above) Form as clear and vivid a mental image as possible of the movement just performed. **DO NOT PERFORM THE MOVEMENT.** Now rate the ease/difficulty with which you were able to do this mental task.

<table>
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<th>Rating</th>
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2. **STARTING POSITION:** Stand with your feet slightly apart and your arms at your sides.

**ACTION:** Raise your right knee as high as possible so that you are standing on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so you are once again standing on two feet. Perform these actions slowly.

**MENTAL TASK:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

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<th>Rating</th>
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3. **STARTING POSITION:** Stand with your feet slightly apart and your hands at your sides.

**ACTION:** Bend down low and then jump straight up in the air as high as possible with both arms extended above your head. Land with your feet apart and lower your arms to your sides.

**MENTAL TASK:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

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<th>Rating</th>
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4. **STARTING POSITION:** Stand with your feet slightly apart and your arms at your sides.

**ACTION:** Jump upwards and rotate your entire body to the left such that you land in the same position in which you started. That is, rotate to the left in a complete (360 degrees) circle.

**MENTAL TASK:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

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</table>

5. **STARTING POSITION:** Extend the arm of your non-dominant hand straight out to your side so that it is parallel to the ground palm down.

**ACTION:** Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly.

**MENTAL TASK:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

<table>
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<th>Rating</th>
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</table>

317
6. STARTING POSITION: Stand with your feet and legs together and your arms at your sides.
ACTION: Make a fist with your dominant hand (the hand you leg extended (do not bend your left knee). At the same time keep your support (right) leg straight. Now lower your left leg so you are once again standing on two feet. Perform these actions slowly.
MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

7. STARTING POSITION: Stand with your feet slightly apart and your arms fully extended above your head.
ACTION: Slowly bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or your hands). Now return to the starting position, standing erect with your arms extended above your head.
MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

8. STARTING POSITION: Make a fist with your nondominant hand. Extend your arm above your head keeping your hand in a fist. Keep your other arm at your side.
ACTION: Swing your extended arm straight down to your side as rapidly as possible. Keep your arm extended and your hand clenched.
MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

9. STARTING POSITION: Stand in front of the floor (exercise) mat with your feet together and your arms at your sides.
ACTION: Perform a front somersault (roll) on the mat and finish in a standing position.
MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

10. STARTING POSITION: Make a fist with your dominant hand (the hand you write with) and then place this hand on the same shoulder (e.g. right hand on right shoulder) such that your elbow is pointing directly in front of you.
ACTION: Extend your elbow so that your hand leaves your shoulder and is straight in front of you parallel to the floor. Keep your hand in a fist. Make this movement slowly.
MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

11. STARTING POSITION: Stand with you feet and legs together and your arms at your sides.
ACTION: Raise your right knee as high as possible so that you are standing on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so you are once again standing on two feet. Perform these actions slowly.
MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating
12. **STARTING POSITION:** Stand with your feet slightly apart and your arms at your sides.  
**ACTION:** Bend down low and then jump straight up in the air as high as possible with both arms extended above your head. Land with your feet apart and lower your arms to your sides.  
**MENTAL TASK:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

13. **STARTING POSITION:** Stand with your feet slightly apart and your arms at your sides.  
**ACTION:** Jump upwards and rotate your entire body to the left such that you land in the same position in which you started. That is, rotate to the left in a complete (360°) circle.  
**MENTAL TASK:** Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

14. **STARTING POSITION:** Extend the arm of your nondominant hand straight out to your side so that it is parallel to the ground, palm down.  
**ACTION:** Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly.  
**MENTAL TASK:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

15. **STARTING POSITION:** Stand with your feet and legs together and your arms at your sides.  
**ACTION:** Raise your left leg as high as possible keeping the leg extended (do not bend your right knee). At the same time keep your support (right) leg straight. Now lower your right leg so you are once again standing on two feet. Perform these actions slowly.  
**MENTAL TASK:** Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

16. **STARTING POSITION:** Stand with your feet slightly apart and your arms fully extended above your head.  
**ACTION:** Slowly bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or your hands). Now return to the starting position, standing erect with your arms extended above your head.  
**MENTAL TASK:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

17. **STARTING POSITION:** Make a fist with your non dominant hand. Extend your arm above your head keeping your hand in a fist. Keep your other arm at your side.  
**ACTION:** Swing your extended arm straight down to your side as rapidly as possible. Keep your arm extended and your hand clenched.  
**MENTAL TASK:** Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.
18. STARTING POSITION: Stand in front of the floor (exercise) mat with your feet together and your arms at your sides.

ACTION: Perform a front somersault (roll) on the mat and finish in a standing position.

MENTAL TASK: Assume the starting position. Form as clear and vivid a mental image as possible of the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating
Appendix 4

STUDY 2: DATA

Table 4.1: Pre and post-intervention performance scores rater 1
Table 4.2: Pre-intervention scores: rater 1_{occasion 1}; rater 1_{occasion 2}; rater 2
Table 4.3: Pearson's correlation coefficients and intra-class correlations
Table 4.4: Responses to Movement Imagery Questionnaire
Table 4.5: Individual responses to planning probes
Table 4.5.1: ANOVA summary of responses to probe 1
Table 4.5.2: ANOVA summary of responses to probe 2
Table 4.6: Breakdown by category of protocol references indicative of planning

Section 4.7 contains sample verbal protocols.
### Table 4.1

**Individual pre and post-intervention performance scores**

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# Table 4.2

Pre and Post-intervention performance scores

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Table 4.3

Pearson's correlation coefficients and intra-class correlations

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<td><strong>Post-intervention performance scores:</strong></td>
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Table 4.4

Responses to Movement Imagery Questionnaire

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Appendix 4

Table 4.5
Individual responses to planning probes

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Table 4.5.1
ANOVA summary of responses to probe 1 (simulated faint)

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Table 4.5.2
ANOVA summary of responses to probe 2 (telephone call)

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### Table 4.6

Breakdown by category of protocol references indicative of planning

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4.7 Sample Protocols

This section contains protocols selected to exemplify the transcription process and provide examples of utterances from subjects in each of the three experimental groups of Study 2. This selection was done on the basis that:

a) the shortest protocol in each experimental group was excluded
b) the subjects did not appear to adopt unusual or idiosyncratic methods

Key

pf = plan formation

pu = plan update or monitoring

pfa = plan failure

*prompts from experimenter are shown in italics*

S6 CT_{rel}

sat down and found out what was wrong with the patient to start with... just to assess the situation and asked her how she was feeling um what exactly she'd had done.... pf

she explained to me that it was her left hip and I'd been told to get her out into the chair.......... so I was finding out as much as I could from her - she also told me that she'd been pf feeling a bit faint and dizzy..........
went over and looked at the drug chart to see what was on there - there wasn't anything that stopped me getting her out of bed - nothing at all....... pf

*what were you thinking at this time?*

um I was like sort of thinking well I don't know really - just how I would sit her up and it just came sort of quite sort of automatically - I don't think I thought about it too much to be honest

um just worked my way through the stages - I knew that what I had to do was get her into the chair...... so I thought I'd position that to start with....... pf

um then I asked her to sit up - she seemed to um not be too bad I thought she'd be able to manage to sit herself up and swing her legs over ...

I was thinking - like supporting her at the back I wasn't taking any weight just my hand was there - but she did seem very heavy when we were there....... pf

but I thought that once she was actually going to be in sitting she'd be OK and she'd manage to do that without too much effort - pu
but she was obviously feeling a bit dizzy so she
went flop so I had to quickly rethink my plan, um...
pu

left her to sort of get her head back and then decided
to roll her and then sit her up
pu/pf
pf

so I wanted her to get back into the middle
pf

so I got her legs back,...... tried to straighten her up a bit
moved her drip out of the way, her drain rather,
out of the way cos I didn't want her caught in it....
pf/pu

then she rolled over um......

*why did you roll her this time?*

just because she went..........., she didn't like going up sitting
pu
before though it wasn't too much of an effort, I just thought
that this would be a slower process and that her head would
slowly be brought up rather than bringing that up first in
pf
that she was feeling a bit faint and a bit dizzy so I
thought she'd respond to it better - its less effort really

she didn't seem too bad when I was sitting her there
pu

*you moved the chair there?*
yes I wanted her just to have the least distance between herself and the chair because she was feeling a bit faint I didn't really want her to walk very much........ pu/pf

and then you moved it again?

yes I think I was just getting it as close as I could really, I moved it and then I thought it could come a bit closer pu

I explained to her what I wanted her to do

.........got her feet into a good position so that she'd find it easy to stand up pf

explained to her to put her arms round my waist so it would be easier for me.... pf

and then coordinate our movements so that we both straightened up at the same time pf

I wanted to keep my back straight which wasn't too bad pf

and then I moved her over to the chair - she wasn't too heavy it was OK..........................

and then wanted her just to sit down as quickly as I could

and then I heard about this telephone call

what did you think then?
....em I just wanted to sit her down as safely and quickly as I could really cos I didn't really know what this phone call was about and I didn't think it was anything to do with the project and thought oh well she can sit down on her own - she's not a real patient - so although I did carry it through I wasn't being as careful as I would have been with someone in pain as I didn't have my full attention on the situation..........

*and what were you thinking here?*

I was still a bit shocked and worried about this telephone call really - it wasn't as bad as I thought it would be and off I went
you're just about to start here

Yes, .. I looked under the blankets to see what was going on \textit{pf}
and found that her legs were crossed so I just wanted to \textit{pf}
uncross them .......

......and then get the bedcovers out of the way so she could move \textit{pf}
freely......

I was just looking at the drain to see how long it was and \textit{pf/\textsc{pu}}
stuff like that where it went then......... um bending her knee up I \textit{pf}
tried to roll her onto her side to make it easier for the \textit{pf}
patient to sit up

then got her legs over the side of the bed to make it easier \textit{pf}
again..................

\textit{what did you think when she slumped on you?}

when she slumped um thought better go back again and try and \textit{pu}
start again ............try and get her to waken up a bit more

......and she did wake up again so just carried on

\textit{and what were you thinking here?}

I don't know what I was thinking actually

\textit{you got her sitting on to the edge}
yes then once I got her up and it was OK not so bad

and what had you got in mind here?

....well the idea was well I moved the chair in closer so it
wouldn't be so far to go and I wanted her to get her hands
around me and underneath so that like in case she panicked
or anything she didn't get around my neck

yes

but um she held on actually quite a lot more than I thought
she would so I had to rethink....

I stepped her round...

then I realised the drain was on the wrong side I had a look
before but I hadn't really thought about it being on the wrong
side so I was going to have to um sort of really move it....

which I do in a minute I think

yes it was attached onto the side.. I probably.. well I
don't know if I should have gone back and then started again
but by the time I'd got to that stage I thought that it
would be easier just to go down but be really careful with the
drain.......  

you're in a bit of a quandary there?

yes she's actually standing up quite well anyway so that's
why we just went ahead think if I had been thinking more I
probably would have

I probably should have sat her down again

*What are you thinking here?*

I was just trying to make her comfortable at the end
you're just coming into view Charlotte

erm I think I was just assessing the situation...looking at whether there was a drain......I don't think I knew what was the matter with this lady so I asked her and thought well there must be a drain somewhere

erm I think I was assessing the situation trying to work out what she could and couldn't do...whether she felt she could move herself at all... mmmm I don't think the patient was very responsive......actually she seemed to be in a lot of pain...I think at the beginning I was trying to work out whether she could sit herself up

....but she couldn't....

I think really I was trying to get everything into my head as in like she's got this kind of problem, this is where her scar is,..this is perhaps what she can and can't do.......I'm going to have to do a certain amount for her...and I think I was quite nervous anyway.............

right because I was going to start moving her with the bedcovers on...because I was just like thinking 'Oh my God I've got to do something'

and er then I realised I had to move the bedcovers..

did that and just went into a kind of routine move, which was if there's a problem around the abdomen then....it was the
abdomen wasn't it..

the hip

oh the hip oh right I see....so it didn't make a lot of sense...
no sense at all doing this

erm but I just went into kind of automatic mode which I'd
learnt to get somebody from lying up to sitting and then sitting
and transferring to a chair.......so I wasn't really thinking very
much about ermm....what the patient could actually do for
herself and what was actually wrong with her, what her own
state was.....I was again very much, I feel, going very much along what
I'd been taught rather than thinking things through'

hence when I got her up and she collapsed it was a complete
shock because I hadn't actually thought it through from the
beginning....I hadn't even considered that might happen

erm then from that point when she was actually sitting and coming
to or even before she'd come to it was ' Oh my God I've got to
support her completely and that was quite er.....

she had a tendency to slump back towards the bed...that was
actually quite a strain....and because it is a back exercise I
was aware of the fact that I'd been out in a situation where I
hadn't even thought about it....that this might happen and you
know I've got to take the load and I remember thinking 'Oooo -
I noticed that'

and then she sort of recovered herself.....
and I was again very much...I feel going very much along what  
I'd been taught rather than thinking things through, though  
actually I mean I feel that was particularly....oh I don't know  
cos I wonder if she couldn't have got herself up a bit more  
you know was what I did really necessary......because I don't think I actually investigated it properly....I don't really think I had to do it like this at all  
that was again classic what we'd learnt... you know get close to the load and all that sort of stuff - use the momentum to get the person up - then I was absolutely petrified she was going to fall over again cos I really thought if she falls now I really don't know what I'm going to do with her.....I'd just have to push her onto the bed  
then you came in (the phone call) and I was actually very engrossed in what I was doing even though I was in a way doing what I'd been taught to do, because the situation was quite demanding because things kept happening which didn't come into the er... what I'd actually been taught, if you see what I mean, and you came in, but I was very focused on what I was doing, I was determined I was going to get this person into the chair  
and I actually believed somebody was on the phone for me that was the other thing, and I thought I've got to get this person sitting in this chair - I viewed her as a patient, a real patient  
erm I didn't feel a strain (back) when I stopped when you came in - it felt comfortable where I was...
but when I was sitting the patient into the chair I realised it was a very deep chair....well it felt very deep - cos it seemed like it was a long way back - and I felt very uncomfortable at that time, it felt like a strain at that particular point.

*you're adjusting the drains?*

yes, well the drain's on the wrong side, and I think it was too short originally to..... when I moved the chair over from where she was sitting I couldn't move the drain round so I had to do it once she'd sat down....unless I'd well I don't know really
Appendix 5

STUDY 3: DATA

Table 5.1: Pre and post-intervention performance scores and self rating scores
Table 5.2: Responses to Movement Imagery Questionnaire
Table 5.3: Breakdown by category of protocol references indicating planning
Table 5.1
Individual pre and post-intervention performance scores and self-rating scores

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Table 5.2

Responses to Movement imagery questionnaire

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Table 5.3
Breakdown by category of protocol references indicating planning

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