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Contents

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The aim of all training is to prepare students for future activities. That is to give them skills which will transfer to different settings. Auto mechanics training prepares mechanics to pull engines apart, repair the faults and put them back together again. Hospitality management training prepares trainees to manage real hotels and holiday resorts. Electrical trades training prepares trainees to read and implement the electrical wiring specifications for houses for clients. The degree to which these outcomes are achieved is the essence of training.

There are many examples of tradespeople with trade qualifications who feel that much of their training was a waste of time and that anything that was of any use to them they learnt on the job. These feelings are also echoed by managers and supervisors. When such feelings become prevalent in a work setting or the wider community they have serious implications for the structuring of curricula to deliver skills that can be transferred to the job.

Today industry requires a flexible work force to cope with rapid technological and economic change to improve economic viability. Knowledge and skills are expected to transfer to new tasks and situations. Workers are expected to relate effectively with other workers and with clients. They are required to learn multiple tasks as workplaces restructure to become leaner and more efficient. With academic credit increasingly being given for prior knowledge and understanding, vocational educators and trainers need to ensure that their assumptions about transferability are based on strong foundations.

The purpose of this paper is to pose issues for consideration by readers, policy-makers and providers of vocational education about the extent to which knowledge, skills and attitudes are transferable from one context to another. It also aims to raise a number of fundamental issues about the transferability of general skills or key competencies. These skills are basic to many tasks, 'apply to work generally . . . and are essential for participation in further education and life more generally' (Mayer 1992, p.5). They include skills in communication, planning, teamwork, and collecting, organising and analysing information. In doing so it necessarily questions some of the basic premises of the National Training Reform Agenda.

To achieve these aims we present a review of the literature on the extent to which knowledge and skills and attitudes learnt in one area do transfer to other areas. We also consider the factors which inhibit or facilitate transfer and the techniques that have been found to be useful for teaching and testing for transfer.

What do we mean by 'transfer'?

When we use the term *transfer* in relation to knowledge, skills and attitudes we generally mean that what is learned in a previous context is either repeated in a similar context or adapted in some way to a new context. In both cases any learning is being made easier by previous learning. This form of transfer has been called *positive transfer*. When previous learning interferes or hinders new learning it is called *negative transfer*.

Positive transfer may occur in a variety of ways. The two most commonly identified ways are *near transfer* and *far transfer*. *Near transfer* involves skills that are learned in one task being applied with relatively few modifications to another task. For example shifting gears in a truck is similar to shifting gears in a car. When a skill learned in one context helps to develop skills in a context which is altogether different it is called *far transfer*. An example of *far transfer* occurs when habits of precision learned in maths are applied to checking for all possible moves in the game of bridge (Perkins & Salomon 1988). Applying general problem-solving or critical thinking skills learnt in a classroom setting to other fields is also an example of *far transfer*. When we talk about *near and far transfer* we are generally discussing the extent to which transfer occurs or the distance it travels from original learning. A brief treatment of the language and concepts used in the transfer literature is presented in Appendix A.

According to Larkin (1989) *transfer* does not just mean applying previous learning to new situations. '*Transfer* means applying old knowledge in a setting sufficiently novel that it also requires learning new knowledge' (p.283). In this paper however *transfer* will be used in connection with knowledge, skills and attitudes which are relatively similar but occur in different contexts as well as those which involve new learning.

Why transfer is important in vocational and general education

Expectations that training in one area will contribute to the learning of skills in other contexts is not a new phenomenon. Over the centuries societies have established training programs aimed at developing skills, knowledge and attitudes that have been considered valuable. Up until the late 19th century, training programs for the nobility and upper classes were based on training the 'faculties' of the mind in the hope that a stronger intellect would be able to deal with problem solving in any environment (Mann 1979). Training for a vocation, generally reserved for the lower social classes, was based on apprenticeship models which involved the apprentice living, working and learning from a master craftsman.

Where the aim of classical education was to discipline the mind by exercising it with difficult cognitive tasks, the aims of modern education are to prepare students to adapt to the world of work and to be useful members of society. The question of whether these aims can be achieved has been asked in both general education and vocational education circles.

Today, as in the past, all educational policy decisions are based on assumptions that learning which has occurred in one context (e.g. schooling) will transfer to another (e.g. university, work, trade training). Reading is taught to enable students to read newspapers and job vacancies, complete tax forms or job applications. Mathematics is taught for its everyday use—giving and receiving correct change, balancing one's financial records and understanding the odds at the races. History is taught to develop an understanding of current affairs. Literature is taught to give students an understanding of life's problems. Thinking skills are taught to produce creative and critical thinkers (Perkins & Salomon 1988).

By and large these courses leave students to make the necessary connections (Royer 1979). Unfortunately many of the connections between contexts are not made. As a result, an increasing number of complaints are levelled against schools, universities and TAFE colleges for producing graduates who are inadequately prepared for the world of work (Bailey 1993, Clark & Voogel 1985, Resnick 1987). Complaints are also being levelled against schools for inadequate preparation of students for higher and further education, and for producing students who do not have basic skills.
With the gradual drying up of unskilled work in advanced industrialised countries it has become increasingly important for students to acquire those skills which will make them marketable in the workplace. This means that schools, universities and TAFE colleges have to put in place programs which will ensure that graduates have the basic numeracy and literacy skills as well as those skills which will help them better adapt to a rapidly changing technological workforce. It is in this context that the transfer of skills has become a critical issue in vocational and general education.

Does training for transfer make a difference—the research evidence

There is little debate about the ability of specific skills learned through training to transfer to similar contexts. For example athletes, gymnasts, dancers, musicians, actors, bakers, butchers, mechanics and dressmakers have learned their arts and crafts through some type of training. As a rule they are able to transfer (with some modifications) the skills they have picked up during training to stages or workshops in different towns and even in different countries. Today the debate centres on the transferability of more general or generic skills which are taught in the hope that they can be applied to different settings.

As we have already noted one of the aims of training is to give trainees and students the knowledge, skills and attitudes to use in later contexts. These aims are founded on the assumption that knowledge, skills and attitudes acquired in one context can help improve performance in another. The problem with this assumption is that it has not always been supported by anecdotal evidence or finding from empirical studies.

In this section we discuss those studies which question the transferability of general and specific skills across situations as well as those that support it.

Training makes no difference

There are countless anecdotal examples of graduates from university, schools or TAFE colleges not being able to apply the general or specific skills they have learned in courses to problems they encounter in the job situation. There are stories of graduates who can not write intelligible sentences or perform basic workplace arithmetical calculations. There are also accounts of skills learned in school settings impeding rather than improving performance on the job. For example, teachers in schools may promote the use of a more formal style of writing than that required in business. This can mean that letters produced by new trainees may tend to sound stuffy and wordy. In a business environment, letters need to be written in language which is straightforward, concise and conveys the desired message. This may require complete retraining in the basics of good letter writing. Constant workplace retraining in skills which have presumably been learnt in schools, universities or vocational colleges leads to frustration with the outcomes of formal schooling.

That transfer is difficult to achieve in different situations was first highlighted in the literature by Thorndike and Woodsworth (1901a, 1901b). These early researchers were interested in measuring the accuracy of subjects' estimations of lengths of lines, areas of shapes, or weights of objects. They were also interested in testing the speed and accuracy displayed by subjects in locating letters in words, and identifying misspelled words and geometric figures. Their findings showed that improvement in the transfer test task only increased when objects or items of similar shape or type to those used in the training were used.

The work of Thorndike and Woodworth was criticised because the tasks were artificial and meaningless to the real world of work. However, when researchers have evaluated transfer in vocational settings, similar results have been obtained. Boldovici (1987) reports studies of weapons systems training in the United States military which collectively showed few transfer benefits as a result of training. Pea and Kurland (1984) also present information which suggests that training in computer programming does not improve 'rigour' in mathematics. Professional abacus users do not do so well when given pen and paper maths tests. (Stigler, Barclay & Aiello 1982 cited in Billett 1994). Brazilian street vendor children who are able to calculate and give correct change to their customers are not able to do well on similar maths problems given in a school setting (Carraher, Carraher & Schlieman 1983 cited by Billett 1994). Furthermore Cronbach and Snow (1977) review a great number of aptitude interaction studies with general education students which also suggest that training has not always resulted in *positive transfer.*

The problem with accepting results of these studies as absolute is that many of the preconditions for transfer may not have occurred and the measures that were used may have been unreliable. Boldovici suggests that the troops and crews in the studies he reviewed may not have had enough practice to become proficient at the skill. They may also have had differential treatment in other areas which may have confounded the results. Salomon and Perkins (1989) suggest that the studies with the computer programming students may also not have given students the required practice to achieve some type of proficiency in computer programming. This could have been responsible for their inability to transfer skills to other contexts.

Training makes a difference

Much of the literature which claims positive results for transferring knowledge gained in one setting to different settings revolves around the teaching of general or abstract rules used in problem-solving, reading comprehension, reasoning and thinking. Supporters of the general thinking skills approach (Ennis 1990, Fong & Nisbett 1990, Fong, Krantz & Nisbett 1986, Herrnstein et al. 1986, Nickerson, Perkins & Smith 1985, De Bono (cited in McPeck 1981, Whimbey & Lockhead 1980, Scheerer 1963) believe that there are definite thinking skills that are common across domains and can be taught as separate skills in programs set up specifically to enhance these skills.

Problem solving—heuristics training

A number of programs have been published to teach people how to improve their problem solving through the use of heuristics. Heuristics are general rules of thumb which will probably, but not always, lead the problem solver to the right answer. Heuristics can be contrasted with algorithms which are formal rules for solving problems which will always guarantee a correct solution.

The aim of the heuristics approach to training is to break down a task into sub-components so that they can be performed more readily. For example a common heuristic for teaching students to be sure that their arithmetic calculations are correct involves checking their answers in the following way: 'Always check your addition of a set of numbers twice. If they vary check them again. When you get the same answer twice you can stop the checking'.

Problem-solving training programs using heuristics ask participants to take personal control of and responsibility for developing their thinking skills. Whimbey and Lockhead (1980) urge readers who aspire to become effective thinkers and problem solvers to be careful and thorough in collecting information and trying to understand ideas and relationships. They suggest a number of strategies for effective problem solving. For example readers need to check continually for accuracy and completeness. Working in pairs and thinking aloud is also promoted as a valuable learning experience for it allows people to compare methods and solutions and to attack problems efficiently and reach accurate conclusions. Breaking a problem down into its component parts will allow problem solvers to work through the problem one step at a time. Good problem solvers avoid guessing, take small careful steps and take care to understand the problem fully and accurately. This careful persistent approach is applied until the problem is solved. Poor problem solvers do not adopt these strategies. In addition they lack confidence and experience and are careless in their reasoning.

These general rules of thumb seem to provide sound advice to those who are impulsive and believe that there is not much they can do to improve their problem solving if an answer is not automatically obvious, or is too difficult to come by. The importance of taking small careful steps, checking for accuracy and understanding should in theory transfer easily to other problem-solving contexts. At the same time however it is also important to realise that if one does not have the background knowledge to understand the facts involved in each small step, having a set of heuristics such as these will not help much.

Polya (1957) has also developed a problem-solving strategy for solving mathematical problems. He has divided the strategy into four stages. In the first stage the problem solver is asked to understand the problem fully. In the second stage the problem solver must recall any successful strategies that have been previously used to solve similar problems and to establish a plan of attack. Once a plan of attack is established the third stage would be to carry out the plan, making sure to check that each step taken is accurate and can be proved. During the last stage the problem solver must examine and check the results obtained. Here it is also important to consider whether the results and the strategies employed can be used for any other problem.

The drawback with this method is that it depends on the problem solver having had sufficient experience with a number of mathematical procedures to even start the first stage. Like all systems it also depends on the motivation of the problem-solver to work through each stage in order to get the correct result. We will deal with the aspect of motivation later on in the paper.

Although many of the heuristics advocated by Whimbey and Lockhead and Polya seem to make sense at face value there is a need for more empirical studies to test whether they do in fact improve performance on a variety of tasks.

De Bono (cited in McPeck, 1981) teaches students to think creatively and productively through a number of programs. In his Cognitive Research Team (CoRT) thinking program he trains students to use a number of operations he calls *spectacles* before solving a problem. In the *Consider all Factors (CAF) spectacle,* students need to list all factors which impinge on the problem. In the *First Important Principle (FIP) spectacle* they must decide which factors are the most important. In the *Plus, Minus, Interest (PMI) spectacle* they must list positive and negative factors for any proposition as well as any factors that may be of interest. In this way students can approach a problem in a systematic way to derive an appropriate solution.

In addition to providing a systematic analytical approach to the solving of problems, De Bono claims that lateral rather than methodical thinking will often generate the creative responses which can help solve difficult problems. It will also lead to inventions responsible for major changes to the ways that things get done. *Lateral thinking* can be described as thinking which is not constrained by traditional ways of viewing or solving problems. These claims however have been criticised on the grounds of lack of empirical evidence (McPeck 1981). McPeck believes that truly creative individuals take advantage of opportunities in their fields not because of some skill at lateral thinking. He feels that creativity is an example of vertical thinking, that is thinking which builds on knowledge that has been accumulated from years of experience. McPeck is also of the opinion that if the only thing that *lateral thinking* does is to generate a large range of new ideas and unusual ways for going about problem solving this may be more a case of *'lateral guessing'* than innovative thinking.

Although McPeck (1981) is right in asking for empirical evidence to support the claims that are often made by De Bono, he may be a little too critical in calling all lateral thinking exercises activities in lateral guessing. There are many examples of productive solutions being developed through De Bono brainstorming techniques which ask groups to generate ideas for solving problems which go beyond established norms. In many management development courses time is given to processes generally known as creative brainstorming activities. Here individuals are presented with a problem and together they come up with crazy or outlandish ideas and strategies for solving the problem. These unusual ideas or strategies then serve as catalysts for the generation of solutions which have the potential to be productive, solve the problem or implement new procedures.

Reading comprehension

Understanding what it is that one has just read is a skill that needs to generalise across subject areas for students at all educational levels as well for all people in their daily lives. A number of studies have found that general strategies for improving a general skill like reading comprehension can be taught (Haller, Child & Walberg, 1988, Brown & Palincsar, 1989). These researchers claim that children can be taught ways to go about reading the material. They can be taught to read textual information backwards and forwards, compare information presented in the text with prior existing knowledge and compare main ideas with each other. They can be taught to check their reading, ask themselves questions about the information and set some goals to follow.

Many of the studies reviewed by Nickerson, Perkins and Smith (1985) and the Herrnstein et al., Brown and Palincsar, and Haller, Child and Walberg studies have used children as subjects. It is important to ask the question whether similar approaches can improve the thinking strategies, and problem solving skills of students, in particular adult students, in vocational education.

General reasoning and thinking skills—the abstract rules approach

The aim of many courses (e.g. statistics, logic, critical thinking etc.) is to develop *reasoning skills* in students so that they can use these skills in their everyday interactions. To stake a claim for the argument that thinking and reasoning skills can be taught separately as a set of general rules, researchers have looked at the impact these courses have had on the everyday thinking of students. They have then drawn conclusions from evidence showing that students have in fact used rules taught during the course to solve problems arising from everyday events. In this section we review a number of studies which attempt to make a case for the teaching of abstract or general rules.

To find out whether general rules training can transfer to problems outside the classroom, Lehmann, Lempert and Nisbett (1988) studied the effect of first year and third year graduate training in medicine, psychology, law and chemistry on statistical, methodological, conditional and verbal reasoning. They found that while statistical and methodological reasoning improved for psychology and medical students, it did not improve for law and chemistry students. Psychology, medicine and law students also improved in their abilities to reason about conditional statements over time. Once again the chemistry students did not improve.

The researchers attributed these results to the fact that the medical and psychology students were taught to apply statistical and methodological rules to scientific and everyday problems. They claimed that these courses alerted students to avoid making conclusions on the basis of small amounts of evidence and small samples, and to make allowances for the effects of confounding and intervening variables. The authors claimed that chemistry and law students were not generally taught these things. As a result they performed less ably than the psychology and medical students.

Moreover the authors claimed that law and medical students are taught to apply reasoning to uncertain everyday happenings. This would improve their ability to use conditional statements (e.g. 'If you are eighteen years old then you are eligible to vote') and biconditional statements (e.g. 'If you are eighteen and registered on the electoral roll, you are eligible to vote').

Although the study of law does not include training in formal logic or statistical and methodological reasoning, it does include training in checking evidence. It also teaches the importance of finding out whether certain activities are either permissible under the law and whether others are demanded or obligatory under the law. The authors argue that chemistry does not expose students to any problems containing ambiguity and uncertainty and as a result does not teach rules that may be relevant to solving everyday problems. The problem with accepting this argument is that the results may well have been more related to the particular courses these students were attending than to chemistry, law or medical courses in general.

Other studies have also found that reasoning can be taught in an abstract way and then applied to everyday life problems (Fong, Krantz & Nisbett 1986, Fong & Nisbett 1991). These researchers trained students in the law of large numbers and then gave them a number of everyday problems to solve. This training emphasised the rule which says that there is less likelihood of sampling error occurring as sample sizes are increased. In particular it related to teaching students not to draw conclusions on the basis of slim evidence. The results showed that when compared to control groups these students did better even when they were not explicitly told to use the rule and when testing took place a long time after training. They also found that it did not matter what type of exemplar information was used.

Amount of training was also found to affect the frequency and quality of statistical responses in the Fong, Kranz and Nisbett study. When answers of PhD level scientists were compared to college students with no statistical training the frequency and quality of correct answers increased dramatically with the overwhelming majority (80%) of PhD level scientists consistently giving more and better answers.

To control for the possible effect of higher intelligence and varied experience with statistical reasoning of the PhD scientists, Fong and Nisbett conducted another experiment. They divided a class list of introductory statistics students into two. Half of the students participated in a test at the beginning of the term and another half participated in a test at the end of the term. Using a method which would not be expected to cue students to use statistical reasoning, the researchers conducted a telephone survey of students' opinions on sport. The results showed that more than twice the number (37% versus 16%) of students at the end of the term gave answers which showed that they had used statistical reasoning as compared to students tested at the beginning of the term. The researchers concluded that statistical training improved statistical reasoning for events associated with uncertainty and probability and that people can apply statistical reasoning to social and non-social events.

Results such as these have been used to support claims for the teaching of reasoning skills through the use of abstract rules. The findings could be taken to support a case for training of general rules unconnected to specific bodies of knowledge. Such results could give hope to those people who believe that there are strategies which can be transported across subject areas to help in problem solving or comprehension. If this is true then the generic or key competencies that have been set up by the Mayer committee (Mayer 1992) may indeed provide guidelines for training in vocational education. Skills such as collecting, organising and analysing information, communicating ideas and information, working with others and in teams, can then be taught in schools or vocational education and training classrooms and workplaces with some confidence that they can be transferred to other places.

The problem with placing too much faith in the results of Fong and Nisbett however relates to some of the shortcomings of their conclusions. They have been criticised for making grandiose claims for evidence which was not very convincing in the first place. Ploger and Wilson (1991) examined the quality of the scores obtained by subjects in this study. These scores showed that whether students were trained or not they did not produce good statistical answers anyway, and that remembering the rule was no guarantee that it could always be applied.

Fong and Nisbett have also been criticised for making too much of their findings that specific knowledge of a subject area makes little difference to being able to remember a rule and apply it successfully. Reeves and Weisberg (1993) feel that Fong and Nisbett may well have found that knowledge of the domain or specific subject area would have affected performance if they had used different measures. As a result they urge caution in adopting an abstract rules approach to problem solving at the expense of using exemplar specific information. Their advice will make even more sense when we examine the factors which influence the development of expertise in our next section.

Strong claims for the transferability of general thinking skills to other areas is also made by Herrstein et al. (1986) in their work with children from economically and educationally deprived backgrounds in Venezuela. Here the researchers used direct instruction methods to teach children a number of cognitive skills. These included observation, classification, reasoning, critical use of language, problem solving, inventiveness and decision-making skills. They taught these skills to children over the course of one year. When results of students in the experimental group were compared to control groups on general and mental ability tests and ability tests based on the skills and processes used in the lessons taught they showed substantial improvements. The course also benefited students across a range of different abilities. Larger benefits however were more generally obtained on tests which measured achievement on items which were closest in type to those that had been taught during the courses.

These last results support Nickerson, Perkins and Smith's (1985) claims that there seems to be some evidence that general skills that are taught tend to transfer to tasks which are similar to the training tasks in which they were acquired. They provide a comprehensive review of a number of approaches to the teaching of thinking and problem-solving skills in which they point to results of studies which show instances of broad and lasting advantages obtained with intellectually retarded subjects and disadvantaged students. If the claims that larger transfer benefits are obtained on tasks that are similar to training tasks are true, then they have implications for the expectations placed on the teaching of general skills that can transfer to a number of occupational settings. More will be made about this point later on in the discussion.

Critical thinking. Another form of reasoning which allows individuals to make rational and well-organised judgements about everyday life events is often called critical thinking. According to Ennis (1989) critical thinking is reasonable, reflective thinking focussed on 'deciding what to believe and do' (p.4). Ennis believes that critical thinking skills can be taught separately using an abstract rules approach which can be applied to a variety of problems.

A major criticism of the general thinking skills or abstract rules approaches has been promoted by McPeck (1981, 1990). This view questions the whole notion of reducing critical thinking to a set of heuristics and strategies which are meant to guide problem-solving. Critical thinking according to McPeck cannot happen in a void. It needs to be embedded in context-specific information.

McPeck (1990) favours the teaching of critical thinking through the traditional disciplines. He believes they can provide the knowledge and the information base needed for rational judgments of scientific and every-day problems. The traditional disciplines provide a large store of relevant considerations. McPeck believes that because of this they reduce the number of reasonable hypotheses that are brought to bear on problems. In this way students can benefit from 2000 years of accumulated knowledge.

According to McPeck the traditional disciplines can promote environments which are conducive to the free exchange and discussion of ideas. The disciplines of science, history, literature and social studies can provide the environment and the knowledge which can nurture this development. They can provide answers to the large questions and pass on cultural traditions. This ability comes from content not from the teaching of abstract rules.

Both McPeck (1990) and Larkin (1983) believe that there are some strategies which can be generalised to apply to a wide number of areas. They also believe that in doing so some of these strategies become almost trivial and as a result lose their effectiveness. General skills which can be applied to a number of areas like not contradicting oneself and not believing what one hears are so general that they cannot be considered to be useful. McPeck is firmly of the opinion that possessing basic knowledge is a prerequisite for the development of critical thinking. Larkin takes a less rigid view and is convinced that both domain or context specific knowledge, and general knowledge which is applicable to a number of domains, can be used in combination to produce transferability. Perkins and Salomon (1988) support Larkin by claiming that local (context-specific) and general knowledge are 'members of the same team that play different positions' (p.31).

It seems clearly not productive to talk in terms of general and specific skills training as alternatives. It would seem more helpful to see them as complementary sides of the same coin. General skills would be quite weak functions if they did not also have a strong base of specific knowledge to support them.

A great deal of support for this position and the preserving of knowledge bases in skill development is provided by the findings of studies of experts and novices. These studies highlight the importance of context specific knowledge and extensive experience in the development of expert skill in problem solving.

The importance of context-specific knowledge in development of expertise—implications for transfer

Interest in looking at the thinking of experts began in the field of artificial intelligence in the sixties and seventies. Here researchers were frustrated by their inability to construct computer systems which could 'act' as intelligently as humans (Chi 1988). As a result they turned their attention to finding out what distinguished the thinking of experts from that of others. In this section we briefly review some of these major findings to support our position that context-specific information needs to be safeguarded in the development of curriculum in vocational education.

Experts have more context-specific knowledge and more experience

Studies of grandmasters in chess (de Groot 1965), experienced taxi-drivers (Chase 1982), senior radiologists (Lesgold, Lajoie, Rubinson, Feltovich, Glaser, Klopfer & Wang 1988), advanced computer programmers (Pea & Kurland 1984), experienced magistrates (Lawrence cited in Voss & Prost 1988) experienced physicians (Johnson cited in Voss & Prost 1988), skilled technicians (Lesgold & Lajoie 1991, Egan & Schwarz 1979) and advanced physics students (Larkin 1983) all point to the large role that context-specific knowledge and experience play in the ability of experts to solve problems. Experts know more and have developed this knowledge through years of experience.

Experts have better organised knowledge structures

Experts have better organised and integrated knowledge structures which they can access readily and easily (Glaser & Chi 1988, de Groot 1965, Bereiter & Scardamalia 1986, Resnick 1987). Novices know less and their knowledge structures are made up of discrete and fragmented pieces of information. A more coherent knowledge structure means that experts are also able to think in terms of underlying principles which can be abstracted and used in other contexts (Larkin 1983, Pea & Kurland 1984).

Experts have more relevant pieces of information

Experts also have more of the most relevant pieces of information (de Groot 1965, Chase & Simon 1973). They know what they are looking for and know how to gather the best information for solving the problem at hand (Johnson cited in Voss & Prost 1988, Lawrence cited in Voss & Prost 1988, Lesgold & Lajoie 1991). Furthermore the recall of specific information is also better in experts. This is not the case for random information. (Chase & Simon 1973, Egan & Schwarz 1979, Erricson, Chase & Faloon 1980).

Experts are able to select the more relevant pieces of information because they can remember responses and principles they have used before to solve other problems. This ability allows them to transform current problems into situations that they have met in the past and apply the principles that have worked at that time. Having access to these prototypical responses means that they can start problem-solving at a more advanced stage (de Groot 1965, Chi 1978).

Experts have better thinking and problem solving strategies

As well as having more integrated information and the most relevant pieces of knowledge experts are better monitors of their own thinking strategies. They are better able accurately to monitor their comprehension. That is, they know more about what they know and do not know (Lesgold & Lajoie 1991, Glaser & Chi 1988). Furthermore poor students are not aware that they have not understood a particular piece of information and often falsely believe that they have understood it (Chi & Bassock 1989). In addition good students ask more questions about the difficult problems; novices ask more questions about easy problems (Glaser & Chi 1988).

When learning new skills or knowledge they look for analogies and provide elaborations on the information presented knowing that this will help them in future learning (Brown & Kane 1989). When good students realise they do not understand a problem it triggers more self-explanations (Chi & Bassock 1989).

In problem solving experts spend more time in problem identification (Purkitt & Dyson 1988) and planning what they are going to do before launching into a solution (Lesgold et al. 1988, Bereiter & Scardamalia 1986) They are able to discard incorrect hypotheses and quickly move to better ones when they come along

(Glaser & Chi 1988, Lesgold et al. 1988). In revising the way they go about doing things they make structural changes rather than surface changes (Brown & Kane 1988, Bereiter & Scardamalia 1986).

Experts have higher intelligence

Intelligence has also been found to be a factor in expertise. Experts in chess have good spatial and verbal ability (de Groot 1965). Experts in computer programming have good mathematical skills, are good at analogical reasoning and have a good sense for making sure that certain steps preceded others (temporal ability) (Pea & Kurland 1984).

Although intelligence has been found to distinguish experts from others it may not on its own be a sufficient account for superior ability in task performance. Yekovich, Walker, Ogle and Thompson (1990) report a study by Walker who found that those who had low intelligence but high knowledge about baseball were better able to recall a passage about baseball than those who had high intelligence but low knowledge about baseball. Yekovich et al. (1990) found that those students who had been categorised as having low aptitude but had a high knowledge of football were able to perform better on a reading comprehension test about football than those of similar ability but with low knowledge of football.

Experts have special ways for handling information

The study of experts and novices has found that in addition to more context-specific knowledge experts also handle information in special ways. They invest time in becoming expert (Bereiter & Scardamalia 1986). They probe underneath the surface features to abstract basic principles when troubleshooting (Larkin 1983, Egan Schwarz, 1979, Lesgold & Lajoie 1991). In reading they go beyond the text and try to integrate what they have read with what they already know (Bereiter & Scardamalia 1986). They provide more and qualitatively better elaborations of what they are reading (Brown & Kane 1988, Chi & Bassock 1989).

Implications for transfer

Although everybody needs to start off as a novice at some time, a picture emerges of experts as having more context-specific knowledge, being more experienced, knowing more about themselves as problem-solvers (meta-cognitive knowledge) and being able to control their thinking in ways which will give them the best results. Such findings further underscore the importance of building up knowledge bases for the development of skill and expertise. Although some strategies may help students to be more efficient learners, it is also important for vocational educators to realise that there are few substitutes for knowledge and experience in the development of expertise and the ability to transfer skills to novel settings.

This information is especially useful in any discussion of what is required for effective skill development and ultimately for transfer.

It can provide trainers with some helpful hints in structuring learning activities which will help people develop strategies that will enhance expertise in a certain area so that transfer to subsequent tasks is made easier.

The finding that the development of expertise has been shown to depend on the repeated performance of a certain skill, and the accumulation through extensive use, of strategies and prototypical responses, provides crucial evidence for the structuring of training activities to incorporate more efficient supports for knowledge acquisition. If we are wanting to develop expertise in any skill, knowledge or attitude then educators in vocational education and training need to ensure that students and trainees are given ample opportunity and time to develop their knowledge and skills.

These findings also raise questions about the wisdom of launching prematurely into a program for multi-skilling trainees in the early stages of their specific trade acquisition. If it takes time to develop skills to expert levels, then the move towards multi-skilling of tradespeople already in the workforce or apprentices in training may need to be re-evaluated in terms of the best time at which multi-skilling is to take place without compromising the development of expertise.

Furthermore there are also implications for the appointment of senior executives in government, business, or industry. In recent years there has been a trend towards appointing executives to head these areas on the basis of a good managerial track record rather than on a thorough understanding of the work they are to manage. If transferability between subject matter areas is limited, and substantial subject matter expertise is required to function efficiently and effectively, then the policy of appointing generalists rather than specialists to head important areas is based on questionable foundations and may also need to be re-examined.

If apprentices, tradespersons and professionals are not allowed to put in the time to develop skills and knowledge to 'expert' levels the whole movement to upskill the workforce to increase Australia's international competitiveness may be thwarted.

Factors which facilitate or inhibit transfer—the research evidence

There may be reasons other than ability to transfer which influence performance on any given task. These include motivation, confidence, original learning, prior knowledge, repeated and varied practice, prompting, task familiarity, task similarity, feedback and ability. In this section we look at the research evidence which led us to this position.

Motivation

Motivation is critical to effective performance in any venture. In transfer terms an individual may or may not be motivated to look for commonalities in previous and subsequent tasks (Bloom, 1976). They may not be interested in searching for strategies that have been successful in the past and implementing these in the new task. Alternatively the task itself may be more motivating and so contribute to more efficient learning. All these factors will have a major influence on how far previous learning will impact on subsequent learning.

Confidence

Closely related to motivation is confidence in one's ability to apply skills learnt in previous situations to new tasks. For example individuals may come up with an appropriate solution to a new task but fail to implement it because they may not have the required confidence to apply it. As a result their ability to transfer may be severely impaired not because of lack of knowledge or skill but because they lacked faith in their own abilities.

Confidence in approaching novel tasks can also affect the way these tasks are performed. We have already seen that experts know more (Chase & Simon 1973, Lesgold & Lajoie 1991) and they know they know more (Lesgold & Lajoie 1991, Chi & Glaser 1988). This confidence may help them to use their information to tackle novel problems in a deliberate and self-assured manner. As well as giving them the inner strength to deal with new situations, this confidence can also inspire confidence from fellow workers. This in turn may work to maintain the self-esteem of experts and further increase their faith in their own abilities.

Confidence for people who have not as yet attained expert status, or who are new to an organisation or job, can take a while to build up. When workers come into a new job they need time to settle into the position, work out the norms and values of the culture, get used to any new equipment, and do their best to perform the new job. All this processing of new information, dealing with emotions and other people can create emotional tension and affect their feelings of self-confidence. This disequilibrium may work temporarily to inhibit prior knowledge from being applied to novel tasks. Once the new employees have settled into the position and are more relaxed in the new social environment they may be better able to retrieve prior knowledge and experience from long term memory and apply it to novel tasks. More research is required to find out just how long this acclimatisation might take for the average worker so that transfer of existing skills can occur in the new workplace.

Original learning

The amount of knowledge we acquire when we first learn a skill can be called 'original learning' (Druckman & Bjork (1991, p37). According to these researchers this plays a major role in transfer. That is to say that transfer increases as a function of the similarity between the stimuli and responses required in training and those required in transfer tasks. In a sense, this is what the work of Thorndike & Woodworth (1901a, & 1901b) has suggested all along.

When different responses are required in the training and transfer task however, the effect of original learning on transfer is less straight forward. Mandel (1968 cited in Druckman & Bjork 1991) found that although *negative transfer* increased as original learning increased, *positive transfer* increased at high levels of original learning. It seems that more training produced 'generalised learning' whose features could counteract 'the negative influences of *response competition* between training and transfer tasks' (p.38).

Prior knowledge

Prior knowledge is information which cues problem-solvers to strategies and information that will give them the correct results. A comprehensive account of empirical studies which examine how prior knowledge improves performance in a transfer task is provided by Bransford (1979). More recently, however, Woloshyn, Pressley and Schneider (1992) have found that Canadian adults who were given information about West Germany, and West German adults given information about Canada were able to perform better in a transfer task asking them to remember these facts than did those who had no prior knowledge.

The presence or absence of prior knowledge will also affect the selection of principles and skills which will be appropriate for solving a problem. McKeachie (1987) explains this effect by examining how using meta-cognitive skills can be affected by prior knowledge. Learning to become aware of one's learning skills and strategies (a meta-cognitive skill) can have both positive and negative effects depending on the individual's position in the learning cycle. In the initial stages of a learning cycle a skill focusing on how one is going about the learning rather than on the information to be learnt may inhibit learning. However once the skill has been attained the awareness of these strategies can facilitate transfer to another skill. Later on a focus on awareness can work to inhibit the automatic functioning of the skill.

Repeated practice

We usually require a number of practice trials before we master a new skill or acquire a new concept. Before we are able to calculate a mean of three numbers easily and without too much thinking we may need to repeat adding the numbers together and dividing the answer by three a few times. Before we can use a new photocopy machine without too much thinking we need to use it successfully a few times. Bransford (1979) has reviewed a number of studies by Nitsch which have looked at how the practice affects transfer. Nitsch found that when subjects were given practice in identifying concepts by remembering prescribed definitions they were able to demonstrate perfect performance after four trials. When they were given a transfer task in which they had to apply the definition to new concepts they did not perform well.

Nickerson, Perkins and Smith (1985) also contend that one of the main reasons that there is a failure of certain skills like thinking skills to transfer to other areas is that skills have been insufficiently learned in the first place. Increasing the time allocated to teaching thinking skills, and the time that students spend on thinking skill tasks can help students to learn skills sufficiently to be able to use them in other contexts. Transfer can also be helped by instructors directing students to use skills in other situations and by giving them practice in making connections to other more remote settings. Repeating the generalised principles in a number of context-free ways and providing stress-free and co-operative environments can be conducive to creative problem solving.

Varied practice

Varied practice is practice involving a variety of examples during training. Nitsch (cited in Bransford 1979) found that subjects who had been given a definition and a variety of examples in which it could be used were better able to transfer this knowledge to the transfer task. This study also supports Salomon and Perkins' (1989) claim that varied practice at the knowledge acquisition stage is an important factor in facilitating transfer.

Gick and Holyoak (1987) also report studies which demonstrate that transfer can be facilitated by providing learners with a variety of examples during training. These studies show that giving learners opportunities to learn from multiple examples can help them abstract general rules that can then be used to solve other problems. Although introducing many varied examples during initial learning may aid transfer if the learning is successful, it has also been shown to impede initial knowledge acquisition (Andrews cited in Gick & Holyoak 1987). It may therefore make more sense to introduce varied practice at a later stage of the learning cycle when knowledge or skill is more firmly developed.

Relying purely on presentation of information rather than varied practice in manipulating it will not allow what Salomon and Perkins (1989) have called 'high road' or 'low road' transfer to occur. It will not give students the amount of practice they need to be able to do it without thinking (low road transfer), and it will not stimulate them to think of other areas where they can use the skill or information (high road transfer). Giving people opportunity to practise a skill so that it can be performed automatically is one way to ensure that it can transfer to novel settings.

Prompting

Prompting is the act of giving subjects clues or cues as to the information or prior knowledge that can be used to help solve a current problem. Gick and Holyoak (1987) have called the transfer that results from this prompting *informed transfer*. *Uninformed transfer* is spontaneous in that it occurs in the absence of such clues. Gick and Holyoak (1987) review studies which they themselves have conducted to show that providing prompts improves transfer in about 75 per cent of cases, and that uninformed transfer can occur when the tasks are perceived as being similar or when they are structured in the same way. Bransford (1979) also reports studies by Bruce and Hannigan which found that suitable prompting can improve people's ability to identify sentences which have been embedded in white noise (a shhh sound used to distort other sounds in order to make them more difficult to identify).

Such studies underscore the importance of previously acquired knowledge and prompting in any transfer task. In a sense they suggest that transfer can best occur when the groundwork has been laid down in the training task, and when participants are helped to make the connections by priming or prompting.

Take the teaching of flow-charting a work process in a cookery course. Here the trainer can first demonstrate the symbols that are used in flow charting e.g., circles for starting and ending points, boxes for work steps, diamond shapes for decision points and down arrows for continuation. The trainer can then ask students to list each step that is involved in the process starting from peeling the potatoes and ending with placing the chips on a side plate ready for serving. Once all the steps have been identified and a flow chart drawn up, the trainees can then set about flow-charting a different process (baking a chocolate cake). In this way, trainees are given practice in using the knowledge or skill that has just been demonstrated.

Once the skill has been learnt the trainer can then inform students that flow-charting can also be used in other areas like mixing drinks, setting tables, arranging invitations and hiring catering equipment. In this way, the ground work has been done. When trainees are subsequently asked to flow-chart other tasks, the trainer can prompt them by asking them to think of the flow-charting process they used in the 'hot chips' example.

Task similarity

The ability to transfer skills from one context to another may also be affected by how similar the transfer task is to the initial learning task and the extent to which it is perceived as being similar by the learner. When a set of rules that have been acquired and been well learned in an initial task can be applied to a transfer task they serve as markers for commonality between the tasks. This allows for *positive transfer* to occur. When rules learned in an initial training task cannot be used in the transfer task then this will impair transfer. A transfer task may be perceived as being similar when it calls up similar goals and processing procedures and looks like an initial task. When this happens learners are more likely to attempt the transfer task firstly because they may feel they have been able to do this before and because the task triggers the retrieval of already acquired knowledge (Gick & Holyoak 1987, Druckman & Bjork 1991).

Task familiarity

Transfer may not occur because the skills have not been learned well in the first place. This contributes to failure to transfer because skills have not been learned to allow automatic processing (Salomon & Perkins 1989). Students may not have been taught when to use the skill that is to be transferred or that a skill is relevant to a new task (Sparrow 1985). Alternatively teachers and students or employers and trainees may not be aware that previous skills are required before a new skill is acquired (Sparrow 1985). Transfer may also not occur because the new skill may involve genuine discovery and it may also depend purely on specific local knowledge.

Cognitive processing

When, during training, individuals need also to cope with changing requirements in the way they process information, perform tasks or practise skills their ability to retain or transfer information is improved (Battig 1979 cited in Druckman & Bjork 1991). Battig suggested that this is because the individual needs to deal with and overcome contextual variety or interference in order to encode the skill and knowledge that is being acquired. This processing creates rich or elaborated knowledge and skill memory structures which are distinctive and then can be retained and accessed more readily during a transfer task.

Feedback

Providing feedback to the subject during the initial learning of a task can also improve learning and in so doing eventually affect transfer. Druckman and Bjork (1991) review studies which suggest that the amount of verbal and non-verbal feedback given learners during training has an effect on learning performance. These studies suggest that feedback which is not frequently given during training or only given at the end of training produces poorer performance during training than feedback given after every trial. However, it has the opposite effect on post-training performance. Here it produces better retention and transfer.

According to these researchers, performance during training may be enhanced by feedback given after every trial because the learner may use it to guide performance. This dependency works against the learner using more complex cognitive processing strategies and generating the rich knowledge and skill structures in memory which can lead to 'transfer appropriate process' (Morris et al. 1977 cited in Druckman & Bjork 1991).

Delaying feedback on the other hand can slow down the rate of learning. Delayed feedback can also have beneficial effects by giving learners an opportunity to experience why certain operations will not produce good results (Lewis & Anderson 1985 cited in Gick & Holyoak 1987).

Ability

We can also never be sure that what we are measuring in the performance of any new skill is not confounded by individual ability. As a rule bright individuals will be aided by their ability either to adapt quickly to new tasks or by their ability to draw on accumulated knowledge. Flexibility in attending to and relating appropriate information to adapt to new tasks has been called fluid intelligence. Knowledge which has accumulated with years of experience or large amounts of exposure to a specific area of information has been called crystallised intelligence (Cattell 1971).

Clark & Voogel (1985) believe that knowing what ability trainees bring to the learning situation can be used to organise instruction. In their opinion those who bring with them highly crystallised intelligence but not fluid intelligence will require extra support in seeing the commonalities underlying the new task or knowledge they have performed in the past. That is they will need to be given help to make analogies. Those who bring with them high fluid intelligence and not crystallised intelligence may need to be given time to accumulate the extra knowledge required for performing certain tasks. Although Clark and Voogel's strategy seems to make sense in theory it is highly unlikely that it would have practical applications in the workplace. Employers would find themselves hard-pressed to implement such a system in terms of time, cost and perceived benefits.

Moreover the problem with believing in ability as a fixed personal attribute is that it does not give much scope for developing those of low intelligence. It may be better instead to see learners as differing in the amount of time they need to acquire knowledge or skill. This view is especially held by Bloom (1976). Bloom believes that slower learners can be helped to learn the same complex skills as faster learners if they are given the time and appropriate instruction. This instruction should take into account the prior knowledge and the individual history the learner brings to the learning situation.

Teaching for transfer—lessons from the literature

Training for transfer is especially valued in terms of young people being able to transfer their skills to new jobs, new technologies and new situations (Matthews 1986). As we have noted before there seems to be considerable evidence to suggest that apart from the transfer facilitating factors we have just reviewed, the other major prerequisites for expertise are a large knowledge base in a specific context and a vast store of experiences. In the case of chess grandmasters it comes partly from playing thousands of chess games. In the case of magistrates it comes partly from having had to deliver a large number of verdicts and sentences. In the case of taxi drivers it comes partly from having used a large number of main and secondary routes to arrive at a destination. In the case of radiologists it comes partly from having analysed a large number of x-rays exhibiting organs with certain malfunctions.

The knowledge component is especially important when we look at developing guidelines for training for expertise and for transfer. It suggests that there may be very few skills which can be performed without some type of prior information or knowledge. This next section examines some of the findings which support a number of strategies for helping trainees or students transfer learning from one area to another.

Understanding how students learn

Our understanding of how one transfers information acquired in one context to solve problems in other contexts necessarily requires us to spend some time spelling out how we believe knowledge or skill is acquired in the first place. That is, what are the factors which influence 'original learning' (Druckman & Bjork 1992). Although we believe that learning is far more complex than any model can portray, the model for learning we have adopted in this paper has borrowed principles from both information processing and behaviourist paradigms for the way we learn.

Lawson's (1992) *Coatsruam Processing Model* of learning has been particularly helpful in suggesting a way that the information processing material can be synthesised into an integrated model. Our model has also been inspired by Lawson's model and the work of Rumelhart and Norman (1981) on schema construction, Piaget (Phillips 1981) on intellectual development, Anderson (1982) on skill development, Gagné (1977) on the conditions of learning, Ferster and Skinner (1957) and Skinner (1938) on reinforcement of behaviour, Brown (1978) on meta-cognitive strategies, and Chi and Bassock (1989) on elaborations.

Because this paper is not primarily concerned with original learning we will not discuss any phase of the learning model at any great length. Instead we will give a brief account of it in order to continue the discussion on transfer. From the outset however we maintain that although the model has described the various phases of learning in a sequential manner, we do not believe that the process is sequential in nature. We hold that there is constant and complex interaction between the phases which have been described.

The environment

When we learn some new information, skill or attitude our learning is influenced by what is going on around us. This includes the physical environment, the instructor, the people learning with us, the equipment we are using and the nature of the information that is being presented. These external influences can either inhibit or facilitate our ability to receive and understand information throughout the learning process.

Readiness to learn

Our readiness to receive the information is also in part determined by our interest in the information, our need to know it, and our particular motivation for learning in general. This readiness will also depend on our physical, physiological, and mental health at the time of learning and our ability to deal with the level of complexity inherent in the information or skill.

Analysing and interpreting the information

When new information is presented to us we create a mental representation or image of it. This mental representation represents our selection and interpretation of the important features of the problem that needs to be solved or the concepts that need to be understood. The extent to which this representation is an accurate reflection of the problem or information will determine how successful we are at analysing it and arriving at a correct solution or acquiring the appropriate knowledge (Lawson & Rice 1987 cited in Lawson 1992, Chi & Bassock 1989).

Manipulating the Information

In order to understand better the information being presented to us we can alter or transform the representation to make it clearer and to fit in with what we already know. This can be achieved by clustering similar elements into groups or categories, or expanding concepts to include richer descriptions and elaborations. Such manipulation of knowledge or skill can ensure that we interpret information in ways which will be productive in learning. Once again the degree to which these self-explanations or elaborations adequately mirror or relate to the principles being presented will also affect successful problem-solving and transfer to new contexts (Chi & Bassock 1989).

As well as manipulating our image of the information being presented, we are also constantly monitoring how, when and why we are doing so. This monitoring can help us decide whether the strategies we are using are leading us in the right direction (Brown 1978).

Storing the Information

Once the information has been suitably restructured and interpreted we store it in memory either by connecting it to knowledge structures we already have in place, or creating new networks to house it. Storing information so that it will endure the passage of time can also be helped by repeated and varied practice.

Attention

Throughout this processing of information our senses are continually being bombarded by other external information or thoughts. These compete for our attention at any given moment. The extent to which we are able to minimise the distraction that comes from this extraneous information will also influence how well we are able to focus on the information being presented to us in order to learn it.

Feedback

Learning information or skill is also highly dependent on the feedback one receives for correct or incorrect applications. Feedback can come from instructors and peers or it can come from interaction with the information itself as it does in trial and error procedures. Positive feedback—praise for work well done—can strengthen or reinforce correct responding. Negative feedback—

disapproval for incorrect responding—can weaken or eliminate wrong decisions.

Using the information in different contexts

The proof that learning has occurred however will only be fully realised once that learning has to be activated. This will in part depend on how easy it is to locate or retrieve the stored information and how well it can be implemented in solving new problems or new tasks.

Although the processes we have discussed are in fact much more complex and interactive than described in this model, viewing learning in this way can help teachers identify those phases of processing which appear to be impoverished. In this way they can work with students to improve the way they go about manipulating the information so that it can be better stored and retrieved.

Protecting traditional disciplines and knowledge bases

Findings that experience and context specific knowledge are major factors in producing expertise have special implications for generic skills training and for vocational educators who are worried about whether generic competencies will transfer from the learning situation to the workplace. The findings from the literature on experts and novices point solidly in the direction of specific knowledge training. This has implications for proponents of the discovery method of learning who generally believe that learning will occur purely as a result of knowing how to access information. Training students how to spend hours in the library searching for information that they can use to prepare a social studies project may be an effective way to teach them research skills but may not be the best way for them to learn basic knowledge about a particular subject or about the issues that may be important.

Such findings also question the wisdom of putting in place a curriculum based on the development of a set of generic skills or competencies and hope that these can be used to prepare students for the world of work. They also suggest a case for protecting the role of the traditional academic, professional and trade disciplines for the building up of these skills and knowledge bases. Embedding training in the context of the traditional disciplines makes sense because they provide a ready-made knowledge base. (Resnick 1987). According to McPeck they provide the main ideas which can form the basis of curriculum design (1991, 1990). The question of how this knowledge learned via these disciplines can be used to help the students transfer what they learn in the classroom to a variety of situations outside the classroom still remains to be answered.

Protecting traditional disciplines and knowledge bases may be one way to ensure that building up context-specific knowledge remains one of the driving forces guiding teaching and learning processes.

Helping students make the connections

The way instruction is delivered can affect the performance of learners (Mayer & Greeno 1972). In one study Mayer (1975) examined how instruction helped students in learning a computer programming language. One group of students was taught about computer functions and given everyday analogies of the different functions. The memory of the computer was likened to a scoreboard, the program to a shopping list and so on. They were also given a ten page document about the language to use. Another group was given the text to read before they heard about how the computer functions could be thought of in every day terms. In the transfer test the first group was able to perform a wider range of tasks. They could better explain what a new program could do and write programs of a type they had not encountered before. The second group was better able to write programs similar to those they had come across in the text.

These findings have special implications for the delivery of training in vocational education. If we want students to be able to use their knowledge to perform a variety of tasks which may be quite different from the tasks they have encountered during training then it is important that we help them to connect their learning to everyday events or the sorts of things with which they are already familiar. This suggests that it is important that this happens at the same time that they are given specific instructions in how to perform certain tasks.

If students only acquire facts without strategies about how, when or where to put these facts to work there is also little hope for any expertise to develop or any transfer to occur (Bransford, Sherwood, Vye & Reiser, 1986, Bransford, Nitsch & Franks 1977, Salomon & Perkins 1989). It seems that facts, strategies and relevant applications of these strategies need to be taught in tandem. Helping students and trainees to make the necessary connections requires trainers and teachers to prompt them to use previously acquired knowledge to help them solve current problems.

The problem of teaching for transfer is still with the teacher in the high school. Swartz (1985) and Bransford (1979) believe that in schools we can teach for transferability by alerting students to take note of how the information can be considered relevant for other contexts. Take the teaching of history for example. Swartz believes that you can teach students to become critical thinkers by becoming 'consumers' of history. He feels that teachers can urge them to stand back from particular examples and reflect on the reliability of eye-witness reports and of sources of information in general. This training can help students to check evidence of source reliability when watching television or reading newspapers or listening to oral reports of national, international or neighbourhood events. If we are to take any notice of the literature which supports the importance of helping students make the connections between what they learn in the classroom and what they do in their everyday lives, then Swartz will also need to provide students with the linkages between what is taught in the history classroom and how they can use these methods to evaluate the reliability of what they read in the newspaper or see on the television.

Developing student awareness

A number of other strategies have been suggested to help students transfer the skills they learn in one situation to another. McKeachie (1987) urges teachers to teach students to be aware of any previous knowledge they have gained which may be relevant to present situations. Although McKeachie accepts the importance of students being able to think in terms of the main principles in solving problems, he feels that teachers should focus on facts when students first acquire knowledge. Thinking in terms of main principles can follow once students have acquired the relevant knowledge (McKeachie 1987).

Developing skills in analysis

What we also know from the study of expertise is that experts perceive problems in different ways from novices. They look for those pieces of information that are going to provide them with the best and most efficient solution. This means that they tend to concentrate on information that is going to be useful (Lesgold & Lajoie 1991, Egan & Schwarz 1979, de Groot 1965). They are also able to do this because their extensive experience or knowledge allows them to perceive the problem in terms of principles that are required for solving it (Larkin 1983). Abstracting underlying principles requires some ability to separate principles from their specific contexts. This ability cannot be developed unless there are efforts to make sure that knowledge that is acquired is accompanied by some explanation of its meaning and of how it can be put to use (Bransford, Nitsch & Krantz 1977).

These findings suggest that we cannot expect students to transfer information spontaneously to other contexts. Transfer cannot happen without teachers or trainers providing some signposts along the way. That is, drawing students' attention to how new information connects to existing knowledge and giving some guidelines as to how skills learnt in the classroom or training room can be transferred to problem solving in the work place.

Teaching students to manipulate information

Teaching students to manipulate the information presented to them is one way to help them increase original learning and eventually increase transfer. Redefining problems can help students to reflect on information and organise it in ways which will help them in other situations as well as transform the problem into components that can be better dealt with (Lawson 1992). It can help them to look for patterns and relationships (Brown & Kane 1988).

Elaborations

Giving students opportunities to provide their own explanations is one way to get them to manipulate information through elaboration and increase their acquisition of knowledge (Wood, Pressley & Winne 1990). When university students were asked to elaborate on why certain events occurred, their learning improved (Woloshyn, Pressley & Schneider 1993 Pressley, Symons, McDaniel, Snyder, & Turnure 1988). Elaborations such as these allowed the learners to transform information into something they could better understand and remember.

Providing information to students which elaborates on the successful use of trained strategies has also been found to improve recall and organisation in transfer tasks. Jackson and Gildemeister (1991) taught students that strategies for grouping items into lots of small groups would help them to remember things more readily than keeping them in one large group. They then gave students feedback which congratulated them on successful performance, and asked them to describe what they had done. Here the researchers provided further explanations on why the strategies the students had used had been helpful and urged them to use these strategies in subsequent tasks. Reminding students of strategies they can use in new tasks has also been found to improve their ability to transfer these strategies to new situations (Gick & Holyoak cited in Brown & Kane 1988).

Self-explanations

The number and quality of self-explanations has also been found to be better in those students who are more successful in problem-solving. Chi and Bassock (1989) found that good students provided almost three times as many ideas for each example as poor students. The researchers believed that in generating these self-explanations the students were actively processing the information as well as adding 'tacit knbwledge' (p281) and that this may have helped them in problem solving.

Analogies

When we view new information in terms of partial similarities to concepts we already know we say we are using analogies. When students have been taught to use analogies by teachers modelling the behaviour and giving them regular practice in using analogies to answer questions their ability to use analogies in other tasks also improved. (Brown & Palincsar Brown 1989, Brown & Kane 1988).

These findings suggest that teaching for transfer requires giving students practice and guidance in redefining and explaining problems in terms of what they already know. Giving students feedback on successful performance, asking them to describe the strategies they have used and once again elaborating for them why these strategies will help them in the future are hints that teachers can use to assist students to transfer knowledge from one situation to another.

A picture is generally emerging of the leading and important role played by teachers and trainers in helping trainees or students to transport knowledge learnt in one setting to solve problems in another setting. This in turn has implications for the development of teaching/training skills for those who are entrusted with imparting knowledge and skill.

Providing authentic learning experiences

There is a general belief that providing opportunities for learning from real tasks that need to be achieved makes for better learning and improves retention. Empirical evidence for this belief has been provided in part by Billett (1994). Billett interviewed coal-workers and workers with at least five years experience in unskilled, semi-skilled, skilled, and professional jobs on how they acquired their skills and what they felt was the ideal mode of skill acquisition. He found that the majority had acquired their skill on the job or in an integrated setting (e.g. a setting which uses on and off-the-job training as in apprenticeships). Most of the workers felt that learning on the job was the most ideal way to develop skill. In addition these authentic experiences allowed individuals to learn skills through trial and error and working independently. They allowed access to knowledgeable others and gave them an idea on how they compared to other novices.

Authentic learning experiences provide opportunities for learners to become active participants in their own learning. Providing such experiences where individuals interact with real objects in real situations on the job has also been found to improve the learning of skills (Greeno 1989). There are also examples of quite sophisticated skills being taught via training on the job. Training medical assistants in developing countries to perform operations generally performed by trained doctors in developed countries is one example of how authentic experience can be used to build up skill bases. If such sophisticated skills that are required to perform medical operations can be taught on the job then it poses problems for the proponents of those who demand that employees need to bring skills (apart from basic literacy and numeracy skills) with them in order to get into the job in the first place. What may be required is the understanding that the job itself will be a training ground for most employees and that what is required is a willingness to learn and to put in a good effort.

Providing authentic learning experiences is what *on-the-job* (as opposed to *off-the-job*) training in industry has always been about. Here supervisors or managers or other workers show trainees what has to be done while working on actual tasks. Although *on-the-job* training whether it be structured or informal, is accessible to those who have jobs and in apprenticeships, it may not be an option for students who are in vocational education preparing to enter jobs. Here *work experience* has been one method of providing some authentic learning for many students.

Work experience

Work experience is the occupational experience that companies give to students in an effort to give them some idea of what it means to work in a certain industry. The problem with *work experience* is that not everyone is sufficiently committed to it. Work places often commit themselves to providing work experience as a favour to schools, TAFE colleges or applicants and finding some job that the work experience student can do is often a last minute decision. Students on the other hand do work experience because it is part of their curriculum. In many offices work experience students are given jobs like filing, photocopying, cleaning up or stuffing envelopes etc. In workshops they may be given jobs like sweeping up, putting the tools away or any other job that many of the regular employees have set aside. As a rule these jobs are jobs that have been waiting to be done but no one really has wanted to or had the time to do them. When work experience is structured in this way it may provide students with the knowledge that there are some jobs that are not pleasant and not difficult but have to be done. It does not however provide the authentic experience that will lead to the learning of skills which are germane to that particular work situation and could not be picked up as a consequence of normal development.

One way to provide students with authentic learning experience is to develop activities whose goals are to develop a certain product. For example a house construction course can actually have students putting a mobile home together, fitting it out with cupboards and furnishings and plumbing requirements, marketing the product and arranging for its sale.

These findings suggest that developing learning tasks which have real end-products as outcomes will give students the authentic experiences which can improve their learning. In a sense there is nothing new in this idea. What is different is that we can now support this with empirical evidence.

Providing opportunities for active participation

Teaching for transfer depends on active participation in knowledge acquisition stages by teachers and students. If students are to be taught to think critically about the news they read in the newspapers, watch on television or hear in the neighbourhood they will need to be given practice in asking the right questions. According to Swartz (1985) teachers can help students to develop these skills by giving them practice in looking for analogies, and providing reasons for their arguments, beliefs and actions. Teachers can help students to think for themselves by providing a climate which nurtures reflection, free debate and the sharing and evaluation of ideas (McPeck 1990, Greeno 1989). They can structure activities which help students develop capabilities to deal efficiently with real tasks in real-life situations (Greeno 1989). This active interaction with knowledge and with others during the acquisition of knowledge has been touted as one way to facilitate transfer across situations (Greeno 1989).

Nickerson, Perkins and Smith (1985) seem convinced that gains can be attained through the structuring of activities to promote interest and participation. They also suggest that effective thinking skills can be promoted by interested teachers who facilitate learning activities in ways which will lead to exploration and discovery of effective strategies. Transfer of skills to other areas can be stimulated by teachers incorporating clear, feasible and measurable instructional objectives into their programs. Transfer can also be promoted by maintaining active student participation in learning and giving them opportunities for adequate skills practice.

Viewing learners as actively interpreting the environment and constructing their knowledge structures in terms of what they already know is the basis for a constructivist model of learning. It can be contrasted sharply with the view of the learner as a passive recipient of information (Greeno 1989). This view however has implications for the delivery of instruction. It can no longer depend on developing curricula which establish the knowledge and skills that will be learned and expecting that learners will acquire these without their active participation in the learning situation.

The findings of the studies on the development of expert knowledge and the teaching of meta-cognitive skills (mental monitoring activities which are concerned with knowing when, how and where one is using information) (Brown & Palincsar 1989, Haller, Child & Walberg 1988) tend to support the case for an apprenticeship model of vocational training where learning is embedded in reality (Putnam, Lampert & Peterson 1980). Here learners are confronted with real world problems and substantial practical guidance and information in developing ways to solve them. They also provide a model for how training for transfer can take place. This model would include the protection of traditional forms of knowledge bases. It would promote direct instruction in how to identify where skills can be used as well as provide for active participation in the acquisition of a skill.

If students in vocational education are to transfer skills they have learnt in the classroom or workshop to tasks they will need to perform in the work place or in everyday life they will need to practise these skills in a variety of situations. Manipulating the information and reflecting on how it can be used in the future can help to ensure that it does not remain buried in long term memory and inaccessible.

These findings show that transfer does not happen in a vacuum. It needs to be nurtured and directed by capable teachers who are expert in guiding students to apply the skills they have learnt in one setting to another.

Teaching for transferability of generic skills

Generic skills are similar to the general skills we talked about before. A more specific definition is provided by Smith (1973) who defines generic skills as those 'overt and covert behaviours which are fundamental to the performance of many tasks and sub-tasks carried out in a wide range of occupations and which are basic to both specialised applications and job specific skills' (p.1). In Australia, Mayer (1992) calls these skills key competencies and says that 'they apply to work generally rather than being specific to work in particular occupations or industries . . . and essential for effective participation in further education and in adult life more generally' (p.5).

Generic skills training depends on the identification of generic skills. Although attempts have been made to identify generic skills, few skills are generic however. Reading skills vary across subject areas. Reading a statistical research report requires different skills from reading a novel. Solving a plumbing problem may be quite different from working out a solution to a baking problem. Even typing skills, traditionally thought of as truly generic, can vary across contexts. Typing financial reports which involve large numbers of tables is different from typing literature reviews which do not require these.

Training reform in Australia and New Zealand has been spearheaded by the development of a set of key competencies (Mayer 1992) or generic skills (Townsend 1993). In Australia one of the Mayer key competencies includes *collecting, analysing and organising information*. The rationale for having this key competency is that individuals in the information based organisations of today need to be able to 'locate information, sift and sort information in order to select what is required and present it in a useful way and evaluate both the information itself and the sources and methods used to obtain it' (Mayer 1992 p.21).

The ability to collect, analyse and organise information can be taught in the context of the various subject areas. Difficulty arises when this ability is expected to transfer spontaneously to different contexts and to work situations. Workplaces have their own preferred ways for doing things and managers and supervisors want things done in a certain manner. Such problems can be solved by ensuring that during induction supervisors, managers or workmates help new workers to understand how it is that certain processes are carried out in the work situation, and give them ample opportunity to adjust to the new expectations.

Another key competency is *communicating ideas and information*. Mayer (1992) claims that all young people need to have "access to all forms of communicative competence" from talking on the telephone to giving a presentation to dealing with an irate customer. Expecting that training will prepare participants adequately for their work roles without prompting and frequent real work place experience in these activities may be asking too much. The ability to communicate effectively on the telephone will develop with knowledge and experience. It will also develop according to the value that is placed on the skill within the organisation by managers and supervisors as well as by work colleagues. The ability to be a skilful presenter of information will depend on familiarity with the information to be presented and the number of times the presentation has been given. Dealing with irate customers will also depend on knowledge of the information that needs to be imparted to the customer as well as the manners that are accepted as desirable within the workplace.

From what we know from the study of experts and informed transfer, few skills can be expected to transfer spontaneously to other settings. What is *needed along with the key competencies is an ability to retrieve relevant knowledge from memory and enough knowledge and experience to be able to function effectively in the new setting.*

Teaching for transfer of dispositional knowledge

Dispositional knowledge is having information about the appropriate values and attitudes that are required for a particular situation. Being punctual, able to manage one's time, cooperative, appropriately assertive and courteous, thoughtful and accurate are all attributes of dispositional knowledge that are desired of workers in modern workplaces. When workers in the Billet studies (1994) were asked for their opinions of what constituted *skilled* work, the frequency with which dispositional knowledge was identified by respondents shows how important the work orientations of workers are to effective skill development. Billett also found that workers needed to understand the concept of work. This means that they needed to show a preparedness or willingness to do the tasks that were required of them on a daily basis.

The importance of dispositional knowledge is also highlighted in the Australian key competencies. *Working with others and in teams* is a key competency which focusses on the ability of the individual to interact with workmates either on an individual basis or in groups to achieve a common goal. It also focusses on the individual's ability to deal with clients in an understanding and effective manner. The problem with focussing on dispositional knowledge as being integral to skilled work is that it is often believed that you either have it or you do not. That is, you are either someone who can co-operate with others to get a job done or you are someone who cannot do it. Although we all have preferences for the ways in which we like to work it is important to train students to develop skills which they will require to work successfully with others.

There are plenty of workplace training programs which teach communication, time management, assertiveness training and teambuilding skills. As a rule principles learnt in the training room however are often not put to use once the employee is back on the job. Dispositions have been built over a lifetime and unless the individual is strongly motivated to change and norms in the workplace are such that sanctions are provided for lateness, inability to meet deadlines, inaccuracy and non-co-operation then there may be little hope for the transfer of skills learnt in a training setting to another context. So long as the responsibility for transfer is embedded in the training, failure to transfer will always be a problem. When support in the form of supervisor expectations and coaching on the job accompanies knowledge acquisition off the job, then there may be much more hope for transfer to occur.

In the school, college or industry training room it might help if these dispositional skills were presented as *organisational survival* skills—skills that are essential if jobs are to be obtained and maintained. Examples of how to project the right attitudes and values, the appropriate ways to behave with bosses or other work mates and how to keep to deadlines will help to create appropriate work orientations and expectations for students. These prepare them to deal better with the work culture once they arrive at the workplace.

Testing for transfer—some useful models

One of the most crucial aspects of research is to develop measures for testing the theory or hypothesis that is being put forward. Assessing the occurrence of the transfer of skills or knowledge is dependent on being able to identify the end skill that is being targetted for transfer, previous knowledge or skill that is thought to influence the acquisition of the targetted skill and working out ways to measure both. As we have already noted the need for training for transfer is valued for providing opportunities for young people to be able to learn skills that they can transport with them to new occupations or tasks. The problem with trying to infer the ability to transfer from perceptions that transfer has occurred is that one can never be sure that it is not some other factor that has contributed to successful performance of a new task (Mathews 1986).

Knapp (1979) has compiled a comprehensive review of the types of tests that can be used to measure transfer. According to Knapp (1979) the assessment of transfer skills 'is the evaluation of the learner to adapt to new work and life situations. It is what she can do or the observed behaviour which shows that transfer has occurred' (p.5). Knapp believes that any assessment procedure should use a number of different types of tasks and be ongoing. It should be connected to the goals of the training and use tasks which are similar to real-world tasks. It should include opportunities for practice and task familiarisation before the testing task occurs. In addition teachers and learners should be given diagnostic or prescriptive feedback.

Assessing cognitive skill

Cognitive skills may be described as mental activities which process information and interpret and order it in meaningful ways. Royer, Cisero and Carlo (1993) have developed an innovative method to assess cognitive skill development. Combining Anderson's (1982) process of skill development with what is known about experts and novices, they have come up with a structure which could be used to help locate a learner's stage of skill development.

Anderson's process is divided into three stages. In the first stage the learner comes into contact with the facts required for the performance of a specific skill. For example a learner involved in a data processing course may be instructed by teachers and use a manual to learn how to set up a spreadsheet. Learning the commands to be used in the initial stages will often require references to the manual. Progress is often one step at a time. This stage of the process takes time. At the end of this stage the learner may be able to answer some questions about the nature of spreadsheets and by consulting the manual he or she will be able to construct a simple spreadsheet by the execution of a few commands.

The next stage is made up of two components. First, a number of steps are integrated into a single step. Each of the procedures are performed in order without the need for consultation of manuals or extended memory searching. This stage speeds up the execution of the skill. Second, the learner is able to decide when to use the particular sequence of actions without consultation. The learner in the data processing course can tailor a spreadsheet to deal with a number of contingencies. This saves time and reduces memory load. .

During the last stage the learner is able to increase his or her reliance on the processes which will speed up the execution of a skill and diminish reliance on those which are slow and cumbersome. Here the learner uses all the facts and procedures learnt in the previous stages to speed up execution into a single step. At this stage the learner in the data processing course will be able to use short cuts to get an effective final result.

In our previous discussion of experts and novices we have seen that experts differ from novices in a number of ways. Experts are able to connect large chunks of information into integrated webs of knowledge. They are also able to assess these integrated webs efficiently and effectively. Novices are only able to access discrete bits of information. Experts tend to go beyond the surface to underlying principles when solving problems. Novices look at surface features. Experts have superior mental models, they know what they know and do not know and are able to perform tasks accurately, efficiently and quickly. Royer, Cisero and Carlo (1993) claim that the extent to which learners resemble experts or novices in these various ways is indication of their current stage of cognitive skill development. That is to say that an individual's performance on a test will determine the degree to which he or she compares with experts and novices. This knowledge can then be used to put in place other training activities which will either refine the skills of those who are more like experts than novices and further improve the skills of those who resemble novices.

Royer, Cisero and Carlo's framework divides cognitive skill development into five major dimensions. These are:

- *Knowledge acquisition, organisation and structure.* During the early stages of acquisition of skill, knowledge or attitudes, a learner stores this information as separate and unrelated facts. As the skill or knowledge develops these units of unrelated facts become closely integrated and form coherent and structured chunks of information. The expert tends to access and use these chunks of information in performing the skill or activity. The novice however accesses and uses only isolated units of information. The extent to which an individual has developed integrated structures or chunks of knowledge can be used as an index of his or her cognitive skill development.

- *Depth of problem representation.* Problem representation refers to the way a problem is perceived by the individual. Experts perceive a problem in terms of principles and concepts. These include the principles and concepts associated with the specific problem as well as with any other related problems. Novices on the other hand perceive the problem in terms of its surface characteristics. The depth of problem representation can also give an indication of the development of a particular skill.

- *Quality of mental models.* A mental model is the ability to picture how a particular skill is supposed to look. Experts have sophisticated mental models of the skills, devices or information they are working with. The presence and elaboration of these models can be an indication of skill development.

- *Efficiency of procedures.* Efficiency is the ability to solve problems by the quickest and most accurate manner. Experts are able to solve a problem by eliminating many of the steps involved in a systematic step-by-step fail-safe procedure. The ability to solve problems in an efficient manner is another indication of skill development.

- *Automaticity of performance.* Automaticity is the ability to perform a task without having consciously to think about it. Novices tend consciously to think about each step they are taking in the performance of a skill. Experts are able to perform the skill without conscious thinking. This means that processing capacity is freed either for planning or integrating aspects of the information being used. This ability is another indication of skill development.

In addition Royer, Cisero and Carlo have identified a number of tests that can be used to measure each stage of their framework. These tests, along with other tests and the strengths and weaknesses associated with each are presented in Appendix B.

This framework attempts to provide a comprehensive system for the measurement of cognitive skills by taking into account the wealth of information that is accumulating on skilled performance, and the multi-dimensionality of cognitive skill. The framework has not specifically been structured to assess the occurrence of transfer or an individual's ability to transfer skills learned in one situation to another. Keeping in mind that we may never be sure that transfer has occurred or that transfer ability may always translate into effectiveness in a new job, the framework can be used as a starting point in developing a system to measure these factors.

Being able to identify a learner's stage of development in a particular skill can help to determine how much more training is required to bring the skill to the automatic stage where the skill can be performed without the individual having to think consciously about it.

The tests identified by Royer, Cisero and Carlo and Knapp can be used to give a measure of an individual's skill development at the time of testing. Vygotsky (1978) would call this a measure of an individual's *actual* developmental level. That is what an individual can do without assistance. According to Vygotsky this can be contrasted with what an individual may be able to do under the guidance of a teacher or in 'collaboration with capable peers' (p.86). A measure of what an individual can do with input from others has been called the *zone of proximal development* or potential development. Vygotsky feels that it makes sense to look at this because what an individual can do with assistance today he or she can do without assistance tomorrow.

Vygotsky was interested in learning and development in children. For our purposes however it also makes sense to think about skill development in terms of what students can do on their own and what they are able to with the assistance of knowledgeable others. More research needs to be done to ascertain whether, in fact, Vygotsky's claim can be supported by empirical evidence.

Conclusions and implications

The studies we have reviewed present a case for the *explicit* teaching of transfer skills where the teaching takes into account the importance of prior and context-specific knowledge. They suggest that teachers will need to help students make the connections between what they learn in the classroom or workshop to what will be required on the job. This means that teachers will need to take on the responsibility for pointing out the relevance and uses of skills they are teaching for other tasks. Because asking students to provide explanations or reasons for certain events has been found to improve later performance it is important that teachers include opportunities for this type of interrogation in their work with students.

In vocational education settings students can be taught to think critically within their specific subject areas by questioning what they read or hear and providing justifications for their reasoning. They can be taught to look for commonalities and to reason by using analogies through guided instruction.

It is also important for teachers of vocational education to understand that spontaneous or uninformed transfer is difficult to achieve. It is also necessary to know that where it does happen it is helped along by having tasks which are perceived as being similar because they evoke similar goals and procedures, or because they can be solved using a set of generalised rules that have been learned in the initial training task.

Findings that experts have high context-specific knowledge and depth of experience help underscore the need for trainees to be given ample opportunity to acquire relevant information and practice in using it. This will have special implications for delivery modes and assessment and selection procedures whether they be in the workplace or in schools. Teaching people how to access information may be useful as a first step in the initial building up of a list of references to be consulted. It should not however be an end in itself. It is the manipulation and understanding of the information that will build up expertise in a specific domain. Asking individuals to perform novel skills without giving them time to familiarise themselves with what is expected and giving some pointers as to how prior knowledge can help them may work against the development of expertise.

This also has ramifications for the orientation of new employees in industry and beginning students in TAFE and universities. New employees will require a settling in period to help them get to know the new social environment and to learn the norms and practices of the organisational culture. It is here that they will require the guidance of knowledgeable supervisors, tutors and peers. If we are to believe Vygotsky that what an individual can do today with assistance he or she will be able to do unaided tomorrow, then it is important to give novices as much help as possible in the learning of new skills and knowledge before any attempts at assessment are undertaken.

We have previously noted that experts are also able to pinpoint those bits of information that will lead to successful and rapid problem solving. They are able to monitor their own performance and have a realistic appraisal of what they can or cannot do. These findings support the case for continuing an apprenticeship model of trade training where novices work alongside 'experts' and gain guided hands-on experience in working on problems that are related to their specific trades. The problem with the apprenticeship model as it is presently structured is that the tradesperson the student is apprenticed to may not be a good role model in all the skills which relate to a specific domain. He or she may not take the time to explain concepts and show apprentices the most important things they need to know to become expert at what they do (of course this may be true of any instructor). What may be required is a system where 'apprentices' are exposed to a range of role models each expert in certain skills with a commitment to teach and collectively representing the skills that are required for a certain domain. In this manner apprentices will be able to acquire the strong knowledge base they require to be proficient in their field, and strategies that will help them speed up their problem-solving processes.

The importance of context-specific knowledge in the development of expertise also has significant implications for the training of generic skills. It questions the transferability of these skills across situations and supports a case for the teaching of generic skills across a range of contexts. In vocational education settings students can be taught to think critically with their specific subject areas by questioning what they read or hear and justifying their reasoning. They can be taught to look for commonalities and to reason by using analogies through guided instruction.

Using Anderson's well established model of skill development and combining this with what is known about experts and novices is one way to test for transfer. This model can be used to help locate where an individual falls on a *skill continuum* which ranges from expert skill to novice skill. This knowledge can help determine further training activities and can also help in allocating tasks to new employees or trainees. What is important however is that this testing does not happen too soon after employees or trainees acquire new skills, knowledge or attitudes for it is varied and continuous practice and experience in using the skill, knowledge or attitude which will bring it up to optimum levels.

In a sense good teaching, be it in the classroom or in the trade workshop, has always been about providing everyday explanations for concepts which may prove difficult to understand. Good teaching has been about allowing students to have the varied practice that will allow them to develop skills to a stage where they are performed without effortful thinking. These findings provide experimental evidence to support the pedagogical knowledge that has been a mark of good teaching and learning accumulated over centuries.

Further research

As has been stated before, the heart of the transfer problem lies in the extent to which training in one context can affect subsequent performance in another. The literature is definite about the role of prior and context-specific knowledge in the development of expertise and successful performance. More work needs to be done to establish how much transfer can be expected from training in similar and dissimilar tasks. It will also be important to examine the impact of factors which can be manipulated by teachers in the training task—feedback, practice, explanation and prompts.

Since the training reform agenda in Australia embraces the notion of key or generic competencies it is especially important to provide empirical support for the assumption that skills like the Mayer key competencies taught in isolation can in fact transfer across situations. Furthermore, it is important to find out how long it takes an average new employee to acclimatise to the new work environment and apply what has been taught in training to real on-the-job processes.

APPENDIX A

Mechanisms which promote transfer

Salomon and Perkins are firmly of the view that it is more fruitful to think about transfer in terms of the mechanisms that promote it.

Positive and negative transfer

According to Perkins and Salomon transfer can be viewed as the *benefit* that is obtained by having relevant skill or background knowledge when learning a new skill. This benefit manifests itself in the time that is saved in learning a new skill or a set of skills because of prior learning (Larkin 1983). When learning one skill contributes to the learning of another skill it can be described as *positive transfer*. For example learning to drive a car strengthens those abilities which are required for driving a truck.

Transfer has also been defined in terms of interferences provided (Perkins & Salomon, 1987, Royer 1979). *Negative* transfer occurs when the learning of one skill interferes with or inhibits the development of another skill. Writing 26 January 1993 on 26 January 1994 is an example of one skill interfering with another. So is using the rules and language of one word processing package when working with another word processing package.

Horizontal and vertical transfer

Horizontal or *lateral* transfer is involved when two tasks are somewhat different and skills learned in one task can be used in the other (Gagn 1965, Salomon and Perkins 1989). Lateral transfer occurs when a skill learned in school like calculating fractions is applied to a domestic problem like working out how many cups of milk will be required to fill a two litre jug. Vertical transfer is involved when the performance of one skill is dependent on the ability to do another. Long division calculations are assisted by the ability to multiply and subtract numbers. Typing on a computer keyboard is aided by previous learning on a typewriter.

Historically psychologists and educators have been more concerned about vertical transfer than lateral transfer. This is because lateral transfer is harder to train for and because educators have not concerned themselves with finding out whether skills learned in school tasks transfer to real world tasks (Royer 1979). In vocational education lateral transfer occupies centre stage. With the introduction of *generic* competencies or skills it is important that these common skills are shown to transfer to a variety of settings.

Common components

According to Salomon and Perkins (1989) and Perkins and Salomon (1989) transfer occurs in a number of ways. Two tasks may exhibit common components. Gear shifting and steering are similar for trucks and cars. Habits learned in one task may be of assistance in another. A preoccupation with precision in maths may lead to a focus on accuracy in bridge. The processing of information in one task may require similar operations of categorisation and memory retrieval in another. The use of problem-solving strategies in one task can be of assistance in finding a solution in another task.

Transfer can also occur as a consequence of practice or a consequence of deliberate mindful efforts to generalise principles from tasks. The first type of transfer has been called *low road transfer*; the second type of transfer has been called *high road transfer*.

Low road transfer

Low road transfer requires practice until the skill is automated and can be repeated in a similar situation. *Low road* transfer is unintentional and is facilitated by reinforcement. Belief systems, expectations, traits and response tendencies are examples of knowledge which has been transferred via the *low road*. Behaviour modelling, socialisation and acculturation promote *low road transfer*. Low road transfer is the normal route to transfer.

Salomon and Perkins believe that learning based on practice has a number of benefits. It is more efficient in carrying out routine tasks. It promotes automatisation which frees mental processing for other activities. This type of transfer, however, can go wrong at the beginning if the skill is not practised correctly. Because knowledge is controlled by the occurrence of certain events, *low road transfer* inhibits analytic reflection.

High road transfer

High road transfer requires deliberate efforts to abstract general principles so that these can be used in different situations. Memory tricks learned for passing school tests can be used to help learn new names. The statistical procedures used in agriculture can be used to work out similar problems in archaeology. The principles used in maths and philosophy can help to inform the viability of ventures into the stock market (Perkins and Salomon 1987). Components of this type of transfer are *backward reaching high road transfer* and *forward reaching high road transfer*.

Backward reaching high road transfer

In *backward reaching high road transfer* a skill that has been learnt in the past is retrieved to assist with a current problem. For example students learn that one way to curb their temper is to count to 10 before making a response. Years later those same students find that they need to control their *impulse buying* tendencies. They reach back and ask 'what have I done in the past to control my impulsiveness?' They comes up with the count to 10 rule. It is said that Gutenberg developed the printing press after having seen a wine press in action (Koestler 1964 cited in Salomon and Perkins 1989).

Forward reaching high road transfer

Forward reaching high road transfer describes a strategy where a skill or piece of knowledge is set up for later use. *High road transfer* then is about transferring certain tools or strategies. It is mindful and deliberate and requires abstraction. Here the student needs to control his or her first response and concentrate on manipulating and reflecting on the information so that it can be understood and put to effective use.

APPENDIX B

Table A1: Techniques for measuring cognitive skill development (based on Royer, Cisero and Carlo 1993)

STAGE OF DEVELOPMENT	TYPE OF TEST	STRENGTHS	WEAKNESSES
Knowledge acquisition	• Traditional tests—multiple choice, true/false etc. • Pairing similarities and differences tests	• Identify facts acquired • Ease of construction • Compare categories of novices and experts	• Difficult to know if learner will be able to use knowledge • Poor predictors of performance after training
Developing knowledge structures	• Reading or listening • Comprehension tasks • Document searches • Computer-based document searches	• Compare with categories made by experts • Measure efficiency of search • Give insight into how tightly knowledge is organised • Indirect measures of knowledge acquired and structure of knowledge • Good for identifying if learner can perform a task • Index of ability to use relevant information for problem-solving	• Computer-based search tasks may be more complex for those who are not comfortable with technology
Problem representation skills Mental models	• Card sorting tasks • Recall tasks • Identification tasks • Classification tasks • Problem-solving tasks • Diagnostic tasks • Prediction tasks	• Help to identify whether learner using appropriate mental models	• Sorting tasks can be cumbersome • May be removed from job performance • Problem may not occur till well after knowledge acquisition
Meta-cognitive skills	• Comprehension monitoring tasks • Think aloud tasks • Strategy implementation tasks	• Can be tied to instructional procedure	• May be influenced by motivation • Difficult to infer thinking from what is said
Automaticity/ Encapsulation of performance tasks	• Speed and accuracy of recall tasks • Sequencing problem-solving steps tasks • Problem-solving tasks • Dual tasks—doing two tasks simultaneously	• Provide valuable index of task expertise	• May be difficult for his/her skill levels • May only be useful for routine tasks

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