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THE TRANSFER OF KNOWLEDGE AND SKILL TO DIFFERENT CONTEXTS

An empirical perspective

JOSIE MISKO

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Executive summary

The question of transfer has always been important through the ages. However it has become even more so in Australia where recent training reform in vocational education has led to the increased use of competency-based training practices based on modularised curricula. When knowledge is packaged into modules designed to deliver certain learning outcomes or competencies there is the danger that such knowledge will never be revisited once a student has demonstrated successful achievement of learning outcomes once the module has been completed.

This publication reports on the findings of two studies—an initial study and a follow-up study. These studies explored the extent to which students are able to retain knowledge or skill learnt in one context and reproduce this knowledge or skill in a different context. Study 1 was conducted with 121 Year 10 students in a country secondary school. Study 2 was conducted with 72 Year 10 students from a metropolitan secondary school.

Students in both studies were required to learn how to construct a pie chart in a mathematics class. They were then assessed on their ability to construct a pie chart from information which described the top 125 businesses in Australia and related industries. This took place in the context of a mathematics class and comprised the initial task. One month later the students were re-assessed for their ability to construct a pie chart from given information in another subject. This comprised the transfer task. In Study 1 students had to construct a pie chart using information on the number of building approvals passed by South Australian district councils in 1992–93. This information was contained on three maps that identified the various council district boundaries. In Study 2 students had to construct a pie chart using information on the number of books published by nine Australian authors. This took place in an English literature class.

The findings showed that there was no guarantee that being able to perform a skill in one context and at one time always means being able to transfer or reproduce the skill in another context. The study also showed that how well the skill is acquired and demonstrated in one context will have a major bearing on how well it is reproduced in another context. In general most students did less well on the major components of the transfer task than they had done in the initial task. However the students who were able to construct the pie chart to higher levels of accuracy in the initial task were more likely to do better in the transfer task than those who had been unable to perform well in the initial task. In addition students in Study 1 who were identified as having higher levels of mathematics achievement by their teachers generally performed better than those of lesser ability. In Study 2 this finding was only evident between the advanced group and the below average group. However even students of advanced achievement level experienced difficulties in transferring the skill to a new context. This tends to suggest that mathematics achievement on its own is no guarantee of transferring mathematics skills to different contexts.

There is nothing unusual about these findings. However there are definite implications for vocational training. This study has shown that substantial numbers of students cannot retain knowledge or skill to a level which enables them to reproduce it in another context. If this is true for all students then the emphasis on a modularised curriculum which often does not allow time for the revisiting of concepts or skills once students have demonstrated successful performance in one situation and at one time may be misplaced. There are also definite implications for the administration of credit transfer and recognition of prior learning.

Do skills transfer?—an empirical study

Background

The success of any training hinges on whether or not skills acquired in training will be used when they are required once the training is over. For example, after we learn to read at school we go on to read newspapers at home or an equipment manual in our place of work. When children learn to do certain things with numbers in a mathematics class it is anticipated that they will be able to do similar things with numbers in a different class while they are still at school or in preparing reports for presentations at work.

When a skill which is learnt in one context or setting is demonstrated in another context or setting it is referred to in the literature as *transfer*. Larkin (1983) and Salomon and Perkins (1987) believe that transfer can be viewed as the benefit which accrues to an individual because of prior knowledge. According to Larkin this prior knowledge helps to reduce the time it takes to learn or to perform a new skill.

According to Perkins and Salomon (1988) learning to drive a truck can be made much easier and quicker if one has already learnt to drive a car. This they feel is an example of *near* transfer. Learning to be precise in mathematics may make it much easier to be careful and thorough in checking for all types of alternatives in bridge. Salomon and Perkins (1987) call this an example of *far transfer*. However Ceci and Ruiz (1993) are of the opinion that the distinction between what is considered to be *near transfer* and what is considered to be *far transfer* is not clear-cut.

The question of *transfer* has always been important through the ages, but it has become even more important in Australian vocational education and training with the implementation of training reforms which are aimed at improving competitiveness in international markets. These reforms have taken place in a climate of high unemployment and increasing criticisms of the low levels of basic skills displayed by secondary school and post-secondary school graduates. Because many traditional low skilled jobs have disappeared or are being performed in off-shore companies, it has become increasingly important for students to be prepared for the more complex jobs which remain.

In such a climate the ability of students to put the skills they have learnt in training into practice once the training is over, has become of special importance to Australian policy-makers, educators, employers, and students. Policy-makers want evidence to show that the millions of dollars being spent on labour market programs and vocational training in general are producing the skills required for a clever and economically competitive country. Educators want to know whether or not they need to keep or modify training strategies to ensure effective skill development. Employers want to know whether or not job applicants really have the skills that their resumés say they have. Students want to make sure they develop the skills they will require for the future and will make them marketable to employers.

When so much responsibility for delivering skills, which will benefit the workplace and eventually the nation, is placed on the school system, the question of whether or not it is reasonable to expect that skills learnt in the classroom will transfer to other areas becomes of major importance. It is appropriate to make use of the concept of *transfer* when trying to answer this question because it is a concept which helps us to describe what happens when young workers take skills they have learned in a school or other training context, and apply them in a work context. If *transfer* has occurred the young person will be able to apply school-acquired skills in the workplace.

The aim of this study is to find out the extent to which skills acquired in one context will transfer to another.

Do skills transfer?—a brief look at the literature

In a previous publication (Misko 1995) I presented an in-depth review of the transfer literature. This literature comprised empirical studies from cognitive science, and educational and social psychology. It examined studies which dealt specifically with the question of transfer and others which were mainly focussed on teaching and learning. Some of this literature is also revisited here.

There seems to be little argument that once specific skills like driving a car, boning a chicken, baking a cake, typing a report, or dancing a step are mastered, they are generally transferred to similar or different settings without too much extra effort. A butcher who has learnt to bone meat in one butcher shop may generally be able to do the same in another butcher shop. A dancer who has learnt to dance a samba in a dancing class may generally be able to dance the samba at any party. Today the transfer debate is more likely to centre on whether or not skills or competencies required for survival and success in the workplace perform in similar ways. That is they are able to transfer from the training situation to the workplace.

In Australia these competencies have been identified as competencies in: communication; using mathematical techniques; planning; teamwork; collecting; organising and analysing information; problem-solving; using technology; and cultural understanding (Mayer 1992). Mayer believes that these competencies (originally known as key competencies) are generic and that all students should be able to demonstrate these on leaving school and entering the workforce. Although few people would debate the importance of such skills for the workplace and for everyday life, what is now being questioned is the assumption that they are generic. That is that skills learned in one context can be applied to other contexts. This debate is fuelled by conflicting evidence from studies looking at the benefits of training, and differences of opinions among researchers about the explanations for these findings. Detterman and Sternberg (1993) present a suite of papers which discuss the extent to which transfer occurs and the evidence that is put forward.

Training makes no difference

According to Ceci and Ruiz (1993) 'the idea that great advances in knowledge and technology have resulted from an individual's ability to transfer solutions across diverse domains is, if not a fiction, a rare event' (p.167). They argue that transfer across domains is more a function of the 'invitation to transfer' that is present in the original learning, along with a comprehensive knowledge of a particular domain so that most problems can be viewed as part of this domain rather than separate from it. That transfer is a rare event is also echoed by Detterman (1993) when he proclaims 'the lesson learned from studies of transfer is that, if you want people to learn something, teach it to them. Don't teach them something else and expect them to figure out what you really want them to do' (p.21). The position taken by Ceci and Ruiz, and Detterman represents a major stream of thought in the debate about transfer.

Some evidence for these conclusions can be traced back to the results of experiments conducted by Thorndike and Woodworth (1901a, 1901b). These researchers measured how accurately subjects were able to estimate lengths of lines, areas of shapes or weights of objects. They also measured the speed and accuracy of subjects as demonstrated in locating letters in words, identifying words that had misspellings and identifying geometric figures. When they gave subjects a transfer test they found that improvement increased only when objects or items of a similar shape or type as those used in training were used. The inability of training to transfer to tasks using items of different types, shapes and sizes gave rise to the identical elements theory which hypothesises that only identical skills will transfer between tasks. The Thorndike and Woodworth studies have been criticised, however, for using tasks which were not relevant to the world of work. At the same time, however, they have been used to defend the position of those who believe that we cannot expect skills to transfer across contexts.

Other researchers have also concluded that training produces few transfer benefits. Findings from studies into the effectiveness of weapons training in the United States military (Boldovici 1987), and computer programming training (Pea & Kurland 1984), have also shown that training does not improve subsequent performance. The Boldovici study showed that weapons training did not help troops to be any better able to use weapons in the field, and the Pea and Kurland study showed that computer programming training did not help students to be more rigorous in mathematics.

Furthermore professional abacus counters did not perform as well on pen and paper calculation tests as they did when they used the abacus for calculations (Stigler et al. 1982 cited in Billett 1994). Street vendor children in Brazil who were well able to calculate the correct change for their customers in the street, were found to be less able to solve similar calculation problems generally done in school mathematics classes (Carraher et al. 1983 cited in Billett 1994). In addition street bookmakers in Brazil who were able to accurately calculate complex combinations for lotteries were unable to transfer this ability to problems which required the same knowledge but used different materials (Schlieman & Acioly 1989 cited in Ceci & Ruiz 1993). Further examples of the inability of individuals to transfer learning to different contexts are contained in studies reported by Cronbach and Snow (1977) and the various papers in Detterman and Sternberg (1993).

It would be easy to conclude from the few studies touched on here and the many studies reported by Cronbach and Snow (1977) and Detterman (1993) that because skills have been found not to transfer between different contexts, any hope for delivering generic skills training is in vain. We must, however, not accept these results without challenging whether or not trainees or students had initially learnt the skills to a proficient level to enable them to reproduce these at a later date (Boldovici 1987; Salomon & Perkins 1989). It seems reasonable to argue that if subjects are not proficient at a skill, even though they have participated in the necessary training, their performance in a transfer task may not be as successful as if they had learnt the skill to a proficient level. This means that their performance in the transfer task will be more a function of their proficiency levels in the original task than an example of their inability to transfer skills across contexts. For this reason it is important to make sure that students do have the skills in the first place before any study of their ability to transfer these skills to different contexts is carried out. The effect of learning on transfer will be discussed in more detail later on in the report.

Training makes a difference

The belief that training makes a difference to subsequent performance of different skills is supported by those who believe that sets of rules can be learned and used to think about and solve problems in a wide range of areas. Supporters of this approach (Ennis 1989; Fong & Nisbett 1991; Lehmann et al. 1988; Fong et al. 1986; Herrnstein et al. 1986; Nickerson et al. 1985; De Bono cited in McPeck 1990; Whimbey & Lockheed 1980; Scheerer 1963; Polya 1957) believe that there are certain thinking and problem-solving skills that are common across domains of knowledge and can be taught in a formal or separate way. Fong and Nisbett, and Fong, Kranz and Nisbett, and Lehman, Lempert and Nisbett provide evidence to show that formal training in statistics and logic can help improve students' reasoning about everyday events.

Whimbey and Lockheed believe that effective problem-solving strategies can be taught. They base their training on the strategies used by good problem-solvers and contrast these with those used by poor problem-solvers. They advise students to take small careful steps, to continually check for accuracy and completeness and to avoid guessing. De Bono urges students to use a set of 'spectacles' in developing thinking skills. These spectacles deal with considering all factors which have a bearing on the problem, listing the most important factors and ascribing positive or negative weighting to each factor.

Researchers working with children from deprived socio-economic backgrounds have also concluded that training makes a difference. Over the course of one year Herrnstein et al. (1986) taught children from economically and educationally deprived backgrounds in Venezuela skills in observation, classification, reasoning, critical use of language, problem-solving, inventiveness and decision-making. When they compared these students to those in a control group their results on a number of tests showed substantial improvements. These improvements were evident across a range of different ability groups.

Haller, Child and Walberg (1988) and Brown and Palincsar (1989) are also convinced that children can be taught to improve general skills like reading comprehension by learning a set of rules for reading. That is they can be taught to read information backwards and forwards, compare what they already know with what exists in a text, and compare main ideas with each other. They can be taught to check their reading, ask themselves questions about the information and set themselves goals from a set of objectives.

Questioning the abstract rules approach to training

The general thinking skills and abstract rules approach to training for improving reasoning about everyday events has been criticised for being based on inconclusive evidence. Fong and Nisbett have been criticised for making claims based on results which showed that subjects did not produce good answers to problems in the initial or transfer tasks anyway, and that remembering a rule did not always mean that the rule could be effectively applied (Ploger & Wilson 1991). They have also been criticised for claiming that knowledge of a particular domain did not affect the ability to remember or apply a rule (Reeves & Weisberg 1993). These researchers feel that different measures would have given less favourable results. As a result caution is urged in adopting an abstract rules approach to training.

Another critic of the general thinking or abstract rules approach to training is McPeck (1981, 1990). McPeck believes that the use of this kind of training to improve critical thinking skills in students is in vain. According to McPeck critical thinking in students can only be developed when it is grounded in context-specific information. This he believes can only be done through the traditional disciplines which can promote the free exchange and discussion of ideas. They can provide the knowledge base to nurture the critical thinking skills of students, and the answers to the large questions which have long perplexed mankind. They can also provide the means by which the traditions of a culture are passed on. Furthermore he does not believe the claims put forward by De Bono because they are not grounded on empirical evidence. Although McPeck concedes that there may be certain strategies that are generic, he is also of the opinion that these strategies are so general that they cease to be meaningful. As a result he feels that the search for a set of generic skills which transcends specific domains is in vain.

The role of intelligence in transfer

Another variable that must not be ignored in the transfer debate is the intelligence or other special individual skills an individual brings to a task. Intelligence and ability tests have been used as a means to predict those who will be able to do well at college, university, and in leadership positions. According to Ceci and Ruiz (1993) the ability to transfer is dependent on being able to think in abstract ways. That is, being able to identify structures or principles which underpin problems. Because by definition intelligent individuals are supposed to be better able to think in such complex ways they are considered to be more likely than individuals of low intelligence to be able to transfer knowledge across domains. Individuals of low intelligence are only likely to exhibit this kind of behaviour when they have large amounts of domain-specific knowledge.

Clark and Vogel (1985) also believe that transfer is a function of intelligence. They are of the opinion that brighter individuals transfer 'farther without instructional help' (p.122) and that the best predictor of transfer is general ability. They also report work by Snow and Lohman (1984 cited in Clark & Vogel 1985) which suggests the inclusion of two different variables to the transfer equation. These variables are crystallised and fluid intelligence. Crystallised intelligence generally refers to skills and knowledge that are amassed through exposure to and experience with similar tasks in the past. Fluid intelligence represents the ability to be flexible in the solution of new problems. Clark and Vogel are of the opinion that although the individual with high crystallised intelligence will succeed in near transfer tasks, it is the individual with high levels of fluid intelligence who will succeed at far transfer.

The role of learning in transfer

Although transfer has often been differentiated from learning by many researchers interested in the concept there are those who also believe that any discussion about *transfer* must treat learning as a sub-component of concept (Ferguson cited in Detterman 1993; Greeno et al. 1993). In addition there are other researchers who believe that it is impossible to distinguish the two (Butterfield et al. 1993).

Greeno, Moore and Smith (1993) provide evidence for the close connection between learning and transfer. In doing so they describe the relativistic position taken by the situated cognition theorists. This position starts from the premise that 'knowing is the ability to interact with things and other people in a situation, and learning is an improvement in that ability—that is getting better in a situated activity' (p.100). According to the situated cognition theorists the social interactions which take place during learning or performing an activity will also affect whether or not individuals categorise the activities which are happening as belonging to a larger knowledge domain. The extent to which they are able to do this will also facilitate or impede their ability to learn in order to transfer knowledge from one context to another, or to relate events in one situation to their previous experience (Brown 1989 cited in Greeno, Moore & Smith).

To try and find out whether learning and transfer were distinct entities, Butterfield, Slocum, and Nelson (1993) examined 13 teaching and testing sets. Within these sets they grouped actions which had been learnt and performed by human and animal subjects into four major categories (see table 7.3). These included:

- previously learned productions or operants (e.g. pigeon will peck for red and not for non red; student will make lemonade when given juice can and all necessary utensils, will ask for spoon when needed to stir coffee, tea etc.)
- test context and goals (e.g. novel hue of red, other colours; experimenter presents everything needed except spoon)
- present action (e.g. pecks key, other response; asks for spoon)
- novel element (e.g. control by a single attribute of the object; addition of novel response to chain)

When they compared these attributes for the 13 teaching and learning sets, they found it impossible to make a distinction between what could be termed as learning and what could be termed as transfer. This led them to conclude that learning could not be distinguished from transfer because each set contained examples of what is generally termed as learning and what is generally termed as transfer across all conditions (see table 7.3; Butterfield et al. 1993, pp.212–214).

The premise that the extent of learning will have an impact on ability to transfer has also been supported by studies which show that the knowledge and experience one has of a particular skill will affect transfer of that skill to a new context. Druckman and Bjork (1991) found that the amount of what they called original learning affected subsequent performance. Woloshyn, Pressley and Schneider (1992) tested Canadian and German adults on geographic details about each other's countries. They found that those with prior knowledge about the country on which they were being tested were better able to perform a transfer task which asked them to recall particular facts about these countries than those who did not have this prior knowledge. That prior knowledge improves performance is also supported by a number of studies reviewed by Bransford (1979) which showed that performance in a task improves when individuals are given cues or prompts to help them recall information.

Perceived similarity between tasks has also been found to improve student performance in a transfer task. That is, students do better when they are given a task they have attempted before or which is similar to a task that they have attempted before (Gick & Holyoak 1987; Druckman & Bjork 1991). This improved performance has been explained by their ability to recognise the goals and problem-solving processes they have used in the initial task (Gick & Holyoak 1987). It seems then that the transfer process is especially sensitive to the amount of knowledge an individual has about the skills that are required in specific tasks.

Transfer and the training agenda

Because the success of the training agenda rests on the skilling of students and workers for a changing and more competitive workplace, it is important to discover the extent to which skills which have been thought to be generic do actually perform in generic ways. That is they transfer across contexts. The answer to this debate has definite implications for how vocational education and training is provided, and how money is spent to support this training.

If those who support the identical elements theory forwarded by Thorndike and Woodworth are right then everything will have to be done to make sure that students are given the requisite skills, knowledge and experience to perform a large variety of tasks before they enter the workplace. It also means that once students enter the workforce they cannot be expected to immediately perform any skills that they have not met before.

If those who support the general thinking and problem-solving approach to training for transfer are right and students can be taught a set of rules to be applied to solve problems in a variety of different contexts, then more emphasis will have to be made in giving students practice in using these skills.

If those who support the belief that transfer is dependent on adequate amounts of context specific information are right, then what is required is a thorough grounding in the information that applies to a particular domain of knowledge.

We need to find an answer to this question before even more millions of dollars are spent on training reform. This study is a small contribution to this endeavour, and will provide some preliminary answers to the question.

Methodology

About the research

This research comprised two studies, Study 1 and Study 2. Both studies aimed to find out whether or not students who were trained to use particular skills in one context (a mathematics class) were able to transfer these skills to another context (a social science class in Study 1, an English class in Study 2). The skills chosen for both studies were the collecting and organising and analysing of information and using mathematical techniques to construct a pie chart from this information. In both studies the task performed in the mathematics class is identified as the initial task. The task performed in the different context is identified as the transfer task.

The rationale for expecting that these skills should transfer between these subject areas is that these techniques are often used to present data in subjects dealing with the humanities.

Subjects

There were two major groups of students who were involved in the study. One group of students was involved in pilot testing the instruments. Another group of students was involved in the main studies. No students who were involved in the pilot testing of instruments were involved in the main studies.

The subjects in Study 1 were 156 students from seven Year 10 classes at a country secondary school in South Australia. Of these, 141 students completed both initial and transfer tasks, and of that number 121 students completed the task without assistance from other students or teachers. All statistics in Study 1 are reported in terms of these 121 students.

In Study 2, 72 students from a metropolitan secondary school completed both initial and transfer tasks.

Procedures

Each study was made of six major phases.

Phase 1: Piloting the tests

Phase 1 included the piloting of tests. The piloting of the tests which were to be used to assess the level of skills acquisition was carried out with two groups of Year 10 students in Adelaide. The test to be used in the mathematics context was piloted with a group of Year 10 students from an advanced mathematics class from a public high school in suburban Adelaide. The tests to be used in the social science context and the English context were piloted with a group of Year 10 students from an advanced mathematics class from a private college in suburban

Adelaide. These pilot tests were used to examine the feasibility of using the test with Year 10 students, and to clarify instructions given to students.

Phase 2: The training of students

Students were given training in the skills to be tested. Teachers in each mathematics class presented students with the skills required to construct a pie chart from given information. This phase took place in the statistics component of the Year 10 mathematics course. They followed procedures set out in the normal Year 10 mathematics curriculum.

Phase 3: Administering the initial task

In this phase the students were given the mathematics test as piloted and modified in phase 1. This test is referred to as the 'initial task'. The initial task was the same for both Study 1 and Study 2. In this task students were given an instruction sheet and two pages of written details of the top 125 private companies published by Business Review Weekly (July 31 1995, pp.66–67). They were instructed to organise the information into industry groupings and to select from these the four most frequently reported industry groupings. They were also asked to place all other industry groupings into a category called 'other'. Using this information they were required to construct a pie chart showing these five groupings.

Students did the test in their class groups. In Study 1 the researcher administered the initial test to six of the seven classes, with one of the mathematics teachers administering the task to the remaining class. The teacher remained in the room but took no part in the administration. In Study 2 the teachers administered the initial test to each class with the researcher monitoring what happened in each of the classrooms.

The instructions were read out to the students and they were asked to work on their own. The researcher wrote the word 'clue' on the student's test paper where help had been received from friends or teachers. These students' results were then taken out of the final analysis.

Phase 4: Administering the transfer task

This phase took place about one month after the administration of the mathematics test or *initial task*. Students were given the social science test in Study 1 and the English test in Study 2. These tasks are referred to as the *transfer task*. The transfer task in Study 1 was administered to students as part of their society and environment class. The transfer task in Study 2 was administered to students as part of their English class.

In the social science task students were provided with an instruction sheet and three maps showing the boundaries of local councils and the number of building approvals that had been passed by each council during 1992–1993. Students were asked to collect data from the information provided and construct a pie chart showing the five councils with the highest number of building approvals, and to place the remainder in a group called 'other'.

The researcher also administered the society and environment test to all the classes. The teacher remained in the room but took no part in the administration. The instructions were read out and students were asked to do as much as they could and to write 'I'm stuck' when they could not do any more. The results of students receiving assistance from any source were removed from the final analysis.

The English task in Study 2 required students to read information on the number of books that had been published by nine Australian authors and poets, and to construct a pie chart showing the four most prolific authors. Students were also required to include books published by the other five authors in an 'other' category.

Phase 5

Immediately after the transfer task students were all given a questionnaire to complete. This questionnaire included the following questions:

1. In which subject did you learn to do a pie chart?
2. How did you know what to do?
3. What did you remember to do first?
4. How did you know the formula for a pie chart?
5. How would you teach a friend to use the pie chart skills learned in maths to solve a pie chart problem in a society and environment class?
6. Why couldn't you remember how to do it?

A small group of students were also interviewed for their opinions on why students may not have been able to transfer skills between contexts.

Phase 6

This phase comprised the analysis of results from students identified as having received no overt help in completing both tasks. Results of tests used in the initial task and transfer tasks and responses to student questionnaires and interviews were analysed. The tasks were broken down into four major components. Separate analyses were prepared for the total group and for males and females and the four levels of achievement groupings. The major components were:

- collecting information
- analysing information
- computing the degrees
- constructing the pie chart

Study 1: Findings

Initial and transfer task performance comparisons

Collecting the information

Collecting the information in the initial task required students to count and write down the number of companies in each industry and to report the four largest industry groupings. It also required them to indicate the number of companies in an 'other' category.

Collecting the information in the transfer task required students to count and write down the number of building approvals for each council district provided, and to report the five councils with the highest number of building approvals. It also required them to indicate the number of approvals in an 'other' section.

In the initial task well under half of the students were able to accurately report the number of companies in each industry. In the transfer task well under a third of the students were able to indicate the exact number of building approvals for each council.

If we accept varying levels of accuracy we find that these numbers increase dramatically. These data are presented in table 1.

Table 1: Collecting information—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	50	41.3	27	22.3	11	9.0	22.0
>=90%	71	58.7	93	76.9	60	49.6	84.5
>=75%	93	76.9	112	92.6	112	71.9	93.5

Analysing the information

In the initial task just over half of the students were able to report the four most frequently represented industry groupings and the number of companies included in the 'other' category. In the transfer task, well under a fifth of the students were able to accurately report the five councils with the highest number of building approvals and the number of approvals in the 'other' category. These data are presented in table 2.

Table 2: Analysing information—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	55	45.5	20	16.5	9	7.4	16.4
>=90%	55	45.5	20	16.5	9	7.4	16.4
>=75%	98	81.0	103	85.1	85	70.2	86.7

From tables 1 and 2 it is evident that far fewer students were able to perform at the 100 per cent level of accuracy in the transfer task than in the initial task.

Students were given points for identifying the correct number of companies in each industry in the transfer task and building approvals in the transfer task. Although a majority of students was able to identify the correct number of companies in each of the industries for both initial and transfer tasks, as a total group they tended to do slightly better in the transfer task than in the initial task.

However there were no major differences between the average scores obtained by the total group for identifying in the initial task the number of companies and in the transfer task the number of building approvals. These data are presented in table 3.

Table 3: Collecting and analysing information—maximum scores, average scores and standard deviations (in parentheses) obtained by total group for initial and transfer tasks

	Initial task		Transfer task	
	Maximum score	Average score	Maximum score	Average score
Identifying number of items in each category	19	15.9 (sd 4.7)	19	17.3 (sd 3.3)
Identifying number of items in most frequently reported categories	10	8.0 (sd 2.8)	10	8.0 (sd 2.1)

Pearson product-moment correlation coefficients for dependent samples for collecting and analysing the information components of the two tasks were computed. Results showed whether in fact those students who had received high scores in the initial task also received high scores in the transfer task. There were no statistically significant relationships between accuracy in identifying correct numbers in the groups to become part of the pie in the initial task, and in accuracy in identifying the number of building approvals for groups in the transfer task or in collecting the information for making these decisions.

Computing values for the components of the pie chart

Applying the formula

Four points were awarded to students if they were able to show evidence of having used all the components of the formula for computing the degrees required for each segment of the pie chart. In the initial task almost three-quarters (70.2%, n=85) of the students were able to produce all the components of the formula. Of these just over half (54.1%, n=46) could reproduce the formula in the transfer task.

Pearson product-moment correlation coefficients for dependent samples were also computed. These showed a moderate and positive statistically significant relationship ($r=.45$, $p=.000$) between scores obtained in the initial task for producing the formula and those for doing so in the transfer task. Not surprisingly, this means that the better performers in the initial task were more likely to get better scores in the transfer task and vice versa. It also means that the lower scorers in the initial task were more likely to get lower scores in the transfer task and vice versa.

A paired-samples test statistic showed that students performed statistically significantly better in the initial task than they did in the transfer task ($t=5.00$, df 120, $p= .000$). The difference between the means was .90 (sd 1.98) with a 95 per cent confidence interval (.519, 1.23). This suggests that students are not always able to transport the skill they can perform in one context to another context.

Positioning the numerator and denominator

If we look at the parts of the formula that students could apply we find that in the initial task about three quarters (71.1%, n=86) of the total group showed evidence of having used the correct position of the numerator and denominator:

e.g. $\dfrac{\text{number of companies in category}}{\text{total number of companies}}$

This means that less than a third of the group (28.9% n=35) were unable to place the numerator or denominator in the right position. Of those who could remember the correct position in the initial task, almost two-thirds (62.8%, n=54) could reproduce it in the transfer task.

Using the x360 format

In the initial task just over half (52.1%, n=63) of the students used the x360 format to compute their degrees. Of these, over two-thirds (69.8%, n=44) reproduced it in the transfer task.

Computing the degrees for each part of the pie

Students were given points out of 20 to indicate the extent to which they were able to calculate the degrees for each component of the pie. In the initial task almost two-thirds (61.2%, n=74) of the students were able to accurately compute the degrees for each part of the pie and obtain the full marks. Of these, about a quarter (25.6%, n=31) were able to do so in the transfer task. If we accept lower levels of accuracy, we find that these figures improve dramatically. Table 4 provides a breakdown of the performance of students at 100 per cent, 90 per cent and 75 per cent levels of accuracy.

Table 4: Computing the degrees for each segment of the pie—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	74	61.2	37	30.6	31	25.6	41.9
>=90%	85	70.2	46	38.0	42	34.7	49.4
>=75%	85	70.2	48	39.7	44	36.4	51.8

The average score received by students in the initial task for this component was considerably higher than that obtained in the transfer task. These results are described in table 5.

Table 5: Computing the degrees for each segment of the pie—maximum score, average score and standard deviations (in parentheses)

	Maximum score	Average score
Initial task	20	13.9 (sd 9.1)
Transfer task	20	8.8 (sd 9.2)

It is obvious from the standard deviation scores that there is a considerable amount of variation between the scores of students for both initial and transfer tasks.

There was a moderate and statistically significant positive relationship between performance in the initial task and performance in the transfer task ($r=.43$, $p=.000$). This means that higher scores in the initial task were associated with higher scores in the transfer task and vice versa and lower scores in the initial task were associated with lower scores in the transfer task and vice versa.

When we examine the differences between the average scores received by students in computing the degrees for each component of the pie chart we find that as a group they performed far better in the initial task. This is demonstrated by the statistically significant test statistic for paired samples ($t=5.78$, df 120 $p=.000$). The difference between the means was 5.13 (sd 9.8) with a 95 per cent confidence interval of between 3.37 and 6.89.

Constructing the pie chart

Each component of the student's pie chart was measured with a geoliner for accuracy. Marks out of 20 were awarded for marking out the segments of the pie chart according to the degrees which had been computed. Results showed that in the initial task well over a half (58.7%, n=71) were able to use a geoliner to accurately measure out each component of the pie according to the degrees they had computed in the initial task. This was contrasted by the smaller number of these students (32.4%, n=25) who were able to reproduce this skill to this accuracy level in the transfer task. In addition considerably more students obtained a zero score in the transfer task than had done so in the initial task.

Data on how well students performed in this component of the task are provided in table 6.

Table 6: Constructing the pie chart—scores obtained in intial and transfer tasks

Scores obtained	Initial task % of students	Transfer task % of students
0	24.0	35.5
1-10	6.6	16.6
11-20	69.4	47.8

A breakdown of how well students performed at 100 per cent, 90 per cent and 75 per cent levels of accuracy also appears in table 7.

Table 7: Constructing the pie chart—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	71	58.7	31	25.6	25	20.7	35.2
>=90%	81	66.9	44	36.4	39	32.2	48.2
>=75%	83	68.6	47	38.8	42	34.7	50.6

When we examine the average scores obtained in the initial task with those obtained in the transfer task we find a moderate and statistically significant positive relationship (r=.45, p=.000) between the two scores. This means that higher scores in the initial task were associated with higher scores in the transfer task and vice versa, and lower scores in the initial task were associated with lower scores in the transfer task and vice versa. It seems that the better you are able to use a geoliner to help you draw a pie chart in an initial task the better you will be at doing so in a subsequent task.

When we compare the means for the two tasks we find that there is a statistically significant difference between the two scores (t=5.82, df 120, p=.000) with students performing better in the initial task than in the transfer task. The difference between the two means was 4.83 (sd 9.13) with a 95 per cent confidence interval (3.19, 6.48).

Labelling the pie chart

The overwhelming majority of students (78.5%, n=95) did not remember to give their pie chart a title in the initial task. An even greater percentage (92.6%, n=112) did not include a title in the transfer task. Of the 26 students who gave their pie chart a title in the initial task, five remembered to do so in the transfer task. These data also show that skills used in one context do not automatically transfer to different contexts.

Six students (4.9%) included a percentage label in addition to the degrees for the angles on their pie charts in the initial task. Only one of these students included it in their pie charts in the transfer task.

Although 11 students included an angle sign on their pie charts in the initial task only four of these included the sign in the transfer task.

Organising the information

Using a tallying or ordering process are ways to organise data. In the initial task 34 (28.1%) showed a formal tallying or ordering process. The overwhelming majority (71.9%) did not use a tallying or ordering process. No student used a tallying process in the transfer task.

Using a table can also help to organise the process for computing the degrees. In the initial task nine students used a table format. Five of these students used a table in the transfer task. The great majority (92.6%) did not use a table to set out their degree computations.

Combining the scores

Students' ability to construct a pie chart from given information was also examined by adding the points they received for accurately collecting the data, analysing the data, producing the formula, computing the degrees and constructing and labelling the pie chart. Initial and transfer tasks received a maximum score of 75 points. Average scores were greater in the initial task than they were in the transfer task. However although there was a greater variation between the scores within each task it was slightly lower for the transfer task. These details are provided in table 8.

Table 8: Overall results—average total scores, standard deviations (in parentheses) and range of scores for initial and transfer tasks

	Maximum score	Average score	Range of scores
Initial task	75	54.9 (sd 24.2)	4–75
Transfer task	75	45.2 (sd 22.0)	2–75

A closer examination of the differences between student performance in the two tasks is presented in table 9.

Table 9: Overall results—scores obtained in initial and transfer tasks

	Initial task		Transfer task	
	No. of students	% of students	No. of students	% of students
0–29	31	25.6	49	40.5
30–69	27	22.3	36	29.7
70–75	63	52.1	36	29.7

It is evident from table 6 that greater numbers of students tended to score at the lower end of the scale. A more comprehensive picture of how students performed appears in table 10.

Table 10: Overall results—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	2	16.5	1	0.1	1	0.1	0.1
>=90%	69	57.0	40	33.1	31	25.6	44.9
>=75%	81	66.9	48	39.7	42	34.7	51.9

A moderate and statistically significant positive relationship (r=.46, p=.000) was found between the total scores in the initial task and those in the transfer task. This means that high scores in the initial task were more likely to be associated with high scores in the transfer task and vice versa and low scores in the initial task were more likely to be associated with low scores in the transfer task and vice versa.

A comparison of the two means using a paired samples t-test shows that students performed better in the initial task than in the transfer task. It returned a statistically significant test statistic of 4.36 (df 119, p=.000). The difference between these means was 9.52 (sd 23.91) at the 95 per cent confidence interval (5.201, 13.847).

General ability in constructing a pie chart

In addition to awarding scores for each of the components, a global judgement based on whether or not students had collected the information, produced the formula and then proceeded to compute degrees and construct the pie chart based on their analysis of the information was also made. This judgement did not demand accuracy at the 100 per cent level in all components although it did depend on the correct formula being used in all cases. This method showed that the ability to construct a pie chart from information that required collecting, organising and analysing, was demonstrated in the initial task by almost two-thirds (70.2%, n=85) of the students. Of these just over half (52.1%, n=45) were judged as being able to construct a pie chart from given information in the transfer task. This also means that almost half of the students who were able to construct a pie chart in the initial task were not able to do so in the transfer task. This information is presented in table 11.

Table 11: Ability to transfer skills between contexts—number of students

	Able to transfer	Not able to transfer	Totals
Initial task			
Not able to draw pie chart	4	32	**36**
Initial task			
Able to draw pie chart	45	40	**85**
Totals	**49**	**72**	**121**

Recalling the general concept

The ability to transfer the general concept was judged by looking at whether or not the students had provided pictorial evidence of what a pie chart generally looked like even though they may not have been able to solve the problem. If students drew a circular shape whether or not they could calculate and demonstrate the angles for each of the segments it was taken as evidence of them having transferred the general concept of the shape of a pie chart. In the initial task the overwhelming majority of students (90.9%, n=110) demonstrated that they had a general idea of what a pie chart entailed. In the transfer task this figure dropped slightly to 82.6% (n=100).

These results suggest that although the specific details of performing a task may not transfer for all people, the general ideas may indeed transfer.

Male and female performance comparisons

There were 65 males and 56 females who attempted both the initial task and the transfer task and did not receive any assistance from any source. Just under one-third (30.4%) of the females were able to construct a pie chart in both tasks. Well over a third of the males (43.1%) were able to construct a pie chart in both tasks. A slightly greater proportion of females (33.9%) than males (20%) was unable to construct a pie chart in both tasks. When we look at the combined scores for each of the components these differences are not statistically significant at the .01 level of significance. More detailed results comparing the performance of girls to boys is presented in table 12.

Table 12: Performance of males and females in constructing pie charts in initial and transfer tasks—number of students

	Able to transfer		**Not able to transfer**		**Totals**
	Males	Females	Males	Females	
Initial task					
Not able to draw pie chart	3 (4.6%)	1 (1.8%)	13 (20.0%)	19 (33.9%)	**36**
Initial task					
Able to draw pie chart	28 (43.0%)	17 (30.3%)	21 (32.3%)	19 (33.9%)	**85**
Totals	**31**	**18**	**34**	**38**	**121**

There are small but not statistically significant differences in the average scores obtained by males and females when their scores for each component of the task are added together.

Means and standard deviations for each component and for the aggregated scores were computed. These are reported in table 13.

A Kruskal-Wallis one-way analysis of variance for ranks test was computed for each component. The results showed that when scores are used there were no statistically significant differences at the .01 level of significance between males and females.

Table 13: Means and standard deviations (in parentheses) for scores obtained in all components by males and females

Components	Initial task		Transfer task	
	Males	Females	Males	Females
Collecting information	15.7 (sd 4.9)	16.1 (sd 4.4)	16.6 (sd 4.2)	17.7 (sd 2.8)
Analysing the information	7.9 (sd 3.0)	8.0 (sd 2.7)	8.0 (sd 2.3)	7.9 (sd 2.0)
Producing the formula	3.1 (sd 1.7)	2.6 (sd 1.9)	2.2 (sd 2.0)	1.7 (sd 1.9)
Computing the degrees	14.9 (sd 8.6)	12.7 (sd 9.6)	10.0 (sd 9.2)	7.4 (sd 9.1)
Constructing the pie chart	14.8 (sd 8.4)	13.0 (sd 9.0)	9.9 (sd 8.7)	8.2 (sd 8.8)
Combining components	56.5 (sd 24.2)	52.9 (sd 24.2)	46.8 (sd 22.5)	43.2 (sd 21.3)

Recalling the concept

In the initial task the overwhelming majority of males (90.8%) and 91.1 per cent of the females demonstrated an ability to transfer the general concept of a pie chart. In the transfer task 82.6 per cent (n=100) were able to show they had the general concept with 80 per cent of the boys and 85.7 per cent of the girls being able to do so.

Performance across teacher-defined achievement groups

Teachers were asked to rate students on a four-point scale based on student achievement of course objectives in mathematics. They divided students into four achievement groups. Accordingly about a quarter (25.6%, n=31) were rated as having achieved objectives to an *advanced* level. Just under a third (30.6%, n=37) were rated as having achieved objectives to a *good* level. About the same percentage (28.9% n=35) were rated as having achieved objectives to an *average* level, and the remainder (14.1%, n=17) as having achieved objectives to a *below average* level. Data on the scores obtained by each of the groups on all components of initial and transfer task are presented in table 14.

The results in table 14 show that in initial and transfer tasks students in higher teacher-identified achievement level groups obtained higher scores than students in lower teacher-identified achievement level groups in all but two cases where the scores were almost equivalent. When the results are examined more closely it can be shown that apart from *collecting the information* and *analysing the information* all groups obtained lower scores in the transfer task than they obtained in the initial task. For *collecting the information* and *analysing the information* the results are reversed. That is, all groups generally performed better in the transfer task than in the initial task.

Table 14: Means and standard deviations (in parentheses) for each component across achievement groups*

	Group 1 (below average)		Group 2 (average)		Group 3 (good)		Group 4 (advanced)	
	Initial task	Transfer task	Initial task	Transfer task	Initial task	Transfer task	Initial task	Transfer task
Collecting information	12.2 (5.4)	15.2 (5.2)	13.8 (5.7)	17.6 (2.9)	18.0 (1.5)	17.5 (2.8)	17.8 (2.9)	17.8 (2.9)
Analysing information	6.1 (3.8)	7.8 (2.3)	7.2 (3.2)	7.6 (2.9)	8.7 (1.9)	8.0 (1.9)	9.2 (1.2)	8.4 (1.1)
Applying the formula	1.4 (2.0)	1.1 (1.7)	2.1 (2.0)	1.6 (2.0)	3.4 (1.5)	2.1 (2.0)	4.0 (0.0)	2.8 (1.7)
Computing the degrees	6.8 (9.5)	5.5 (8.4)	9.7 (10.1)	7.2 (9.3)	16.6 (7.4)	9.1 (9.4)	19.7 (0.6)	12.2 (8.7)
Constructing the pie chart	7.0 (9.3)	4.7 (7.9)	9.8 (9.7)	7.3 (8.5)	16.7 (6.8)	10.4 (8.5)	19.7 (7.0)	12.5 (8.4)
Combining components	33.7 (23.9)	34.3 (21.5)	42.7 (27.3)	41.3 (21.0)	63.8 (16.1)	47.5 (20.7)	70.9 (4.7)	54.0 (20.0)

*Teacher-identified achievement groups: Groups 1–4

Table 15: Mean ranks for each component across achievement groups*

	Group 1 (below average)		Group 2 (average)		Group 3 (good)		Group 4 (advanced)	
	Initial task	Transfer task	Initial task	Transfer task	Initial task	Transfer task	Initial task	Transfer task
Collecting information	34.7	40.6	44.0	65.0	74.0	60.0	76.4	66.6
Analysing information	39.9	59.7	51.4	60.5	67.3	57.8	73.9	64.4
Applying the formula	38.7	46.4	48.4	54.4	67.8	62.7	77.5	72.4
Computing the degrees	35.9	49.2	48.7	54.9	69.4	60.7	76.7	72.8
Constructing the pie chart	38.4	42.8	45.1	50.7	71.4	66.1	77.0	74.6
Combining components	28.0	41.1	44.2	53.4	71.0	63.5	84.0	73.7

*Teacher-identified achievement groups: Groups 1–4

When we take the differences between the scores obtained for *computing the degrees* and *constructing the pie chart* in the two tasks, we find that although the higher achievement level groups performed better than those of lower achievement they also obtained higher difference scores. This means that their scores in the transfer task deviated more markedly from their scores in the initial tasks than the scores of the lower achievement level groups. This is especially evident when we add the scores obtained for each component and examine this total as a final score.

A Kruskal-Wallis one-way analysis of variance for ranks test was applied to determine whether differences between the groups were statistically significant. This showed that in the initial task group, differences were statistically significant at the .01 level of significance for all areas. Group differences in the transfer task were only statistically significant at this level for *constructing the pie chart* and *combining the components*. Group differences in *applying the formula* were only statistically significant at the .05 level of significance. There were no other statistically significant differences.

A breakdown of the mean ranks for each of the components appears in table 15.

When we look at the global judgements for competence in both tasks just over half (54.8%) of the *advanced* achievement level group demonstrated competence as compared to just over a third of the *good* (40.5%) and just under a third of the *average* (31.4%) achievement level groups. Only two of the *below average* group were able to do so.

Transfer strategies reported by successful and unsuccessful students

All students were asked to complete some questions on the strategies they had used to carry out the transfer task. The responses of the 45 students who were able to construct the chart in both contexts and the 40 students who were able to do it in mathematics and not able to do it in the society and environment class were examined separately. Not all students provided an answer for all questions.

The majority of both successful (82.9%) and unsuccessful students (84.7%) indicated that they had learned how to do a pie chart in mathematics. When they were asked how they knew what to do almost half (44.7%) of the successful students based their knowledge on their ability to 'remember' what to do. Of these a third of the students reported that they had remembered these skills from mathematics classes.

The findings for the unsuccessful students showed that seven (17.5%) attributed their skills to remembering and ten (25.0%) to their teacher showing them what to do in mathematics. Table 16 details the variety of strategies used by successful and unsuccessful groups in response to the question 'How did you know what to do?'

Table 16: Strategies reported by students in answer to question: *How did you know what to do?*—number of students

Strategy	Successful students	Unsuccessful students
Remembered	21	7
Asked questions	3	0
Teacher showed/told me	16	10
Trial and error	3	0
Practised over and over	1	1
Learnt skills not long ago	3	0
Was told	0	1
Thought about it	0	1
Don't know	0	1
Listened and followed instructions	0	2
Learnt it in maths	0	2
Guessed	0	1
Learnt it	0	2
Could only remember so far	0	1

Students were also asked what they remembered to do first. No strong trends were evident in the responses of both sets of students. Their responses appear in table 17.

Table 17: Responses to question: *What did you remember to do first?*—number of students

Response	Successful students	Unsuccessful students
Work out number, convert to percentage and multiply by 3.6	2	0
Divide number by total and multiply by 360	3	0
Collate information	3	1
Draw table	1	2
Remember formula	1	0
Work out totals	6	3
Divide by total number	1	0
Work out degrees for each segment	4	1
Multiply by 360	3	0
Remember totals and formula	1	0
Draw circle	3	5
Collect data and order high to low	1	0
Find percentage	1	2
Remembered 360 degrees in a circle	1	0
Divide by 3.6	0	1
Multiply by 3.6	0	2
Add/count	0	5
Use compass	0	1
Divide 360 by 100	0	1
Find percentage, multiply by number and divide	0	1
Read question and look through information	0	1
Write my name	0	1
Find five highest	0	1
Multiply x 360 and divide	0	1
Tally up	0	1

From this information we can see that the preliminary procedures reported by successful and unsuccessful students vary. Those reported by successful students seem to be strategically useful and geared to the correct completion of the task. Those reported by unsuccessful students often deal with less important issues and sometimes with incomplete logic.

When students were asked how they knew the formula for the pie chart, 11 of the successful students reported that they *remembered*. There were no further explanations regarding how they remembered. Six students said that the teacher had taught them and ten that they had learnt it in mathematics. For the unsuccessful students the responses were somewhat more varied. Table 18 presents the responses for successful and unsuccessful students to the question 'How did you know the formula?'

Table 18: Student responses to question: *How did you know the formula for the pie chart?* —number of students

Response	Successful students	Unsuccessful students
Remembered	11	4
Teacher showed me	6	6
Learnt it in maths	7	3
Learnt it	3	1
Just knew	0	1
Forgot	0	1
I did not	0	1
Can't remember	0	1
Sort of remembered	0	1
Looked in a book	0	1
I'm smart	0	1

Students were also asked how they would teach a friend to use the pie chart skills learnt in mathematics to solve a problem in a society and environment class. The most favoured methods reported dealt with *showing, telling* and *explaining*. Table 19 presents these details for successful and unsuccessful students.

It is interesting to note that only a few of the unsuccessful students recognised that they were unable to do it and as a result they would not even try to teach the friend.

Table 19: Student responses to question: *How would you teach a friend to use the pie chart skills learnt in mathematics to solve a problem in society and environment?*— number of students

Response	Successful students	Unsuccessful students
Tell them the formula/memorise formula/ drum formula into their heads	9	2
Use same method as in mathematics	5	2
Explain and help them	1	0
Explain degree conversion and use of protractor	1	0
Ask teacher	0	3
Show them the way I do it	4	2
Show them step by step	1	2
Tell them how to draw up the table and to divide *n* by total and multiply by 360	1	0
Tell them to multiply by 360	1	1
Demonstrate it to them	0	2
Show them a recent pie chart	0	1
Don't know	0	2
Can't	0	1
I wouldn't	0	2
Add to get each number	0	1
Multiply by 3.6	0	1
I have no idea	0	1
Divide the data by 360 and multiply by 100	0	1

Students were also asked for reasons as to why they had been unable to construct the pie chart. Not all the students who were unable to transfer the skills recognised that they did not know how to solve the problem. Reasons that were given by those who recognised that they had not been able to do the transfer task were:

- did not think about it enough
- have not done it for a while
- don't know
- I forgot
- because it is difficult
- my calculations did not work out
- I don't understand any more but was okay in maths
- I could not be bothered
- I can't remember, memory loss
- did not know we were doing it
- I'm not good at remembering
- I haven't practised it enough

Six of the students claimed to have successfully completed the pie chart even though their subsequent results were to show that they had not completed it to the required standard.

A number of successful students were interviewed briefly for their opinions of why students who may have reported using similar strategies (i.e. learned how to do a pie chart from the teacher and relied on their memories) may have been unsuccessful. The general opinion from these students was that such students may not have listened carefully in class, and may have needed to be shown many times before they would be able to perform a skill. Some of the other reasons provided were:

- I pay attention and others don't care
- it may have been too complicated
- some people are slower, you have to show them a lot
- it sticks with some, others are not thinking about it
- others haven't listened
- others don't pay attention

These results suggest that successful students are not completely aware of the strategies they employed to transfer the skills from a subject like mathematics to a subject like society and environment.

Overview of findings

This study has shown that there is no guarantee that being able to perform a skill in one context always means being able to transfer the skill to another context. However, it seems that whether or not the skill is acquired at a proficient level in the first place has a major bearing on how well it transfers to a new context.

In addition the study has found that students of higher mathematics achievement level as defined by their teachers are in most cases more likely to be able to transfer the skill to a new context than are those of lower achievement. However, because substantial numbers of those of high achievement also found it difficult to transfer the skill to the new context, we can say that achievement level in mathematics on its own is no guarantee of transfer.

Follow-up study

Study 2 was conducted to see whether in fact similar results were obtained using the same initial task and a different transfer task. Efforts were also taken to remedy some problems experienced in the previous study. The findings of Study 2 are presented in the following section.

Initial and transfer task performance comparisons

Collecting information

The initial task used in the first study was repeated in this study. Here just over half of the students were able to identify the number of companies in each industry to the 100 per cent level of accuracy. In the transfer task this figure fell dramatically. Here minimal numbers of students were able to correctly identify the number of books published by each author. Only one student who was able to perform at the 100 per cent level in the initial task was able to do so in the transfer task. This figure climbs to 11 if we accept at least a 75 per cent or above score in the transfer task.

When we accept at least 90 per cent and 75 per cent levels of accuracy as baselines for both tasks we find that few students were able to perform at the 90 per cent level in both tasks. More than a third of the group were able to perform at the 75 per cent level in both tasks.

Table 20: Collecting information—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	39	54.1	3	4.2	1	1.4	2.5
>=90%	48	66.6	3	4.2	1	1.4	2.0
>=75%	61	84.7	36	50.0	30	41.6	49.2

From table 20 it appears that there is a very large difference between the numbers of students able to perform at the 90 per cent level of accuracy in the initial task and those being able to do so in the transfer task. These numbers may be a function of the marking system. Students lost points for not providing the exact number of items in each category. In the initial task they needed to obtain at least 17.1 points to score at the 90 per cent level. Because only whole points could be lost for each inaccuracy, this means that in this task they could afford to get only one of the categories wrong to obtain this score. However if they lost one point in the transfer task they could only ever obtain a score of 88.9 per cent.

It makes more sense for this component to speak about the number of errors made in each task. When we allow for one counting error in initial and transfer tasks we find that more than two thirds (67.8%, n=50) of the total group was able to perform at this level in the initial task. In the transfer task this number continued to fall dramatically with still only a fifth (20.2%, n=15) being able to perform at the same level. Slightly fewer (14.9% n=11) were able to perform at this level in initial and transfer tasks.

An average score of 16.7 (sd 4.3) was obtained for the initial task. An average score of 13.1 (sd 3.5) was obtained for the transfer task. Pearson product-moment correlation coefficients showed no statistically significant relationships between scores obtained in the initial task and scores obtained in the transfer task at the .01 level.

Analysing the information

Students were awarded a maximum score of 10 points if they could identify the correct number of items for each of the five frequently reported categories, based on their calculations in the collecting information stage. If they had lost a point for inaccuracy in the collecting information stage they were not penalised in the analysing information stage.

In identifying the number of companies required for each segment of the pie chart the percentages of students performing at the 100 per cent level of accuracy in the initial task was higher than the percentage of students being able to perform at this level in the transfer task. Whereas two-thirds of the group were able to perform at this level in the initial task, just over a third were able to do so in the transfer task.

Just over a third of those who had received the maximum score for analysing the information in the initial task were able to gain the same score in the transfer task. However if we take the number of students able to perform at the 100 per cent level of accuracy in the initial task and accept at least a 90 per cent level of accuracy in the transfer task this figure climbs to just over a half (52%, n=26) of the group.

However if we take at least a 90 per cent or a 75 per cent level of accuracy as baselines for performance in initial and transfer tasks then the number of students able to perform at these levels increases considerably. These data are provided in table 21.

Table 21: Analysing information—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	48	66.6	25	34.7	16	22.2	32.0
>=90%	48	66.6	36	50.0	26	36.1	52.0
>=75%	56	77.8	45	62.5	37	51.3	66.1

Pearson product-moment correlation coefficients showed there were no statistically significant relationships between initial and transfer task scores.

Average scores also showed that students performed at a higher level of accuracy in the initial task than in the transfer task. These are detailed in table 22.

Table 22: Collecting and analysing information—maximum scores, average scores and standard deviation (in parentheses) obtained by total group for initial and transfer tasks

	Initial task		Transfer task	
	Maximum score	Average score	Maximum score	Average score
Identifying number of items in each category	19	16.7 (sd 4.3)	19	13.1 (sd 3.5)
Identifying number of items in most frequently reported categories	10	8.5 (sd 2.6)	10	5.9 (sd 4.5)

Computing values for the components of the pie chart

Applying the formula

In the initial task almost all (95.8%, n=69) of the students demonstrated that they had used all the components of the formula. Just over two-thirds (63.9%, n=46) could do so in the transfer task. This represented two-thirds of those who had been able to apply the formula in the initial task.

Positioning the numerator and denominator

The overwhelming majority of the students (95.8%, n=69) were able to demonstrate that they had correctly positioned the numerator and denominator in the initial task. Over two-thirds (62.5%, n=45) of these were able to do so in the transfer task.

Using the x360 format

In the initial task well under half (43.0%, n=31) of the students used this format to arrive at the angles to be used for measuring out the segments of the pie. Just over two-thirds of these (58.1%, n=21) reproduced it in the transfer task.

Computing the degrees for each part of the pie

In the initial task just over half of the students were able to calculate the degrees for each segment of the pie to the 100 per cent level of accuracy. This figure dropped to well under half in the transfer task. Of those who were able to accurately calculate all the angles for all segments of the pie chart in the initial task well under half could do so in the transfer task. This figure increases at lower levels of accuracy. For example, of those who could accurately compute the degrees in the initial task over half (58.3%, n=21) could perform at the 90 per cent level of accuracy in the transfer task.

If we take both 90 per cent levels of accuracy and 75 per cent levels of accuracy in initial and transfer tasks then these figures climb dramatically. Almost two-thirds of those who were able to perform at this level in the initial task were also able to perform at this level in the transfer task. These data are detailed in table 23.

Table 23: Computing the degree for each segment of the pie—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	36	50.0	33	45.8	16	22.2	44.4
>=90%	56	77.8	43	59.7	36	50.0	64.2
>=75%	65	90.3	46	63.9	45	62.5	69.2

Average scores obtained for this component of the task also decreased markedly in the transfer task. These details are provided in table 24.

Table 24: Computing the degrees for each segment of the pie—maximum score, average score and standard deviations (in parentheses)

	Maximum score	Average score
Initial task	20	17.5 (sd 5.1)
Transfer task	20	12.5 (sd 9.4)

It can be seen from the standard deviations in table 24 that there is considerable variation between the scores obtained for the initial task. However this figure is almost doubled in the transfer task.

There was also a moderately positive statistically significant relationship between student scores in the initial task and their scores in the transfer task. This is demonstrated by a Pearson product-moment correlation coefficient ($r=.33$, $p.005$). This means that students who obtained higher scores in the initial task were more likely to obtain higher scores in the transfer task and vice versa and students who obtained lower scores in the initial task were more likely to obtain lower scores in the transfer task and vice versa.

A comparison between the means showed a mean difference of 4.97. This comparison returned a statistically significant t-test for paired samples ($t=-4.64$, df 71, $p=.000$) at a 95 per cent confidence interval of between 7.11 and 2.83.

Table 25 provides a detailed description of how students performed in initial and transfer tasks.

Table 25: Calculating the degrees for each segment of the pie chart—varying levels of accuracy

Scores obtained	Initial task		Transfer task	
	No. of students	% of students	No. of students	% of students
0	5	6.9	25	34.7
1-10	0	0.0	1	1.4
11-15	5	6.9	1	1.4
17-19	26	36.1	12	16.7
20	36	50.0	33	45.8
Totals	**72**	**100.0**	**72**	**100.0**

Constructing the pie chart

In the initial task just over half of the students were able to use a geoliner to accurately measure out each segment of the pie according to the degrees that had been originally calculated. In the transfer task this figure was reduced to a third. Just under half of those who obtained the maximum score in the initial task also obtained the same score in the transfer task. When we accept a 90 per cent or 75 per cent level of accuracy in the transfer task there is a slight increase. Of those students who were able to perform at the 100 per cent level of accuracy in the initial task just over half (53.7%, n=22) were able to perform at the 90 per cent level of accuracy in the transfer task.

When we accept the 90 per cent and 75 per cent levels of accuracy for both tasks we find that at the 90 per cent level of accuracy just under half of the students were able to perform at this level in initial and transfer tasks. At the 75 per cent level of accuracy this number climbs to well over half. A breakdown of these data appears in table 26.

Table 26: Constructing the pie chart—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	41	56.9	26	36.1	20	27.8	48.7
>=90%	42	58.3	32	44.4	22	30.6	52.4
>=75%	52	72.2	39	54.2	33	45.8	63.5

An average score of 15.3 (sd 7.1) was obtained in the initial task. In the transfer task this figure was reduced to 11.2 (sd 9.0). Data on how well students performed in both tasks appear in table 27.

Table 27: Constructing the pie chart—scores obtained in initial and transfer tasks

Scores obtained	Initial task		Transfer task	
	No. of students	% of students	No. of students	% of students
0	7	9.7	23	31.9
1-10	8	11.1	7	9.7
11-15	5	6.9	6	8.3
16-19	11	15.2	10	13.9
20	41	56.9	26	27.8
Totals	**72**	**100.0**	**72**	**100.0**

A moderately positive statistically significant relationship (r=.39, p=.001) was also discovered between scores obtained in the initial task and scores obtained in the transfer task. This means that better performance in the initial task was more likely to be associated with better performance in the transfer task and vice versa. It also means that weaker performance in the initial task was also associated with weaker performance in the transfer task and vice versa.

The difference between the means for both tasks was 4.1. The comparison between the means returned a statistically significant value (t=3.89, df 71, p=.000) with a 95 per cent confidence interval of between 2.008 and 6.242. This showed that students did significantly better in the initial task than in the transfer task.

Labelling the pie chart

Just under half (47.2%, n=34) of students remembered to give their pie chart a title in the initial task. Just under a fifth (19.4%, n=14) remembered to do this in the transfer task. Of those who had remembered to provide a title for their chart in the initial task just under a third (29.4%, n=10) also provided a title for their chart in the transfer task.

Nine (12.5%) students incorporated an angle sign in the initial task. Of these only two students provided an angle sign in the transfer task.

Thirteen students (18.1%) provided both a percentage label and an angle sign in their charts in the initial task. Only four of these remembered to do so in the transfer task.

Organising the information

In the initial task about a third (29.2%, n=21) of the students used a tallying process to collect their data. Of these only three remembered to do so in the transfer task.

Just over half (54.2%, n=39) of the students remembered to draw up a table to organise their calculations for each segment of the pie. Just over a half (51.2%, n=20) of these remembered to use a table in the transfer task.

Combining the scores

Students could obtain a maximum score of 75 for both initial and transfer tasks. The average score obtained for the initial task was 62.3 (sd 14.2). The average score obtained for the transfer task was 45.8 (sd 24.8). The standard deviation scores show us that although there is considerable variation between the scores obtained in the initial task, this variation is almost doubled in the transfer task. No student who obtained full marks in the initial task was able to do so in the transfer task. Nor was any student who obtained full marks in the initial task able to obtain a 90 per cent mark in the transfer task. However if we accept a 90 per cent level of accuracy in both tasks then the number of students who were able to perform at this level in the initial task and in the transfer task increases considerably. It is even greater when we accept a 75 per cent level of accuracy. This number more than doubles if we accept a 75 per cent level of accuracy in both tasks. These data are presented in table 28.

Table 28: Overall results—varying levels of accuracy

	Initial task		Transfer task		Both tasks		
	No. of successful students	% of total group	No. of successful students	% of total group	No. of successful students	% of total group	% of successful students in initial task
100%	2	2.8	0	0.0	0	0.0	0.0
>=90%	36	50.0	19	26.4	13	18.1	36.1
>=75%	56	77.8	40	55.6	38	52.8	67.9

From table 28 it is evident that just over a third of those students who were able to perform at the 90 per cent level in the initial task were able to repeat this performance in the transfer task. This more than doubles when we accept a 75 per cent level of accuracy.

A more detailed view of how well students performed in scored components of both tasks is provided in table 29.

Table 29: Overall results—scores obtained in initial and transfer tasks

	Initial task		Transfer task	
	No. of students	% of students	No. of students	% of students
1-10	0	0.0	2	2.8
11-20	4	5.6	22	30.6
21-30	0	0.0s	2	2.8
31-50	4	5.6	3	4.7
51-60	16	22.2	9	12.5
61-70	26	36.1	28	38.9
71-75	22	30.6	6	8.3

Pearson product-moment correlation coefficients showed a moderate and positive statistically significant correlation ($r=.44$, $p=.000$) between the scores obtained by students in the initial task and those obtained in the transfer task. This means that students who performed at a higher level of accuracy in the initial task were more likely to perform at a higher level of accuracy in the transfer task and vice versa. Students who performed at a lower level of accuracy in the initial task were also more likely to perform at a lower level of accuracy in the transfer task.

The difference between the means was 16.5. A paired samples t-test returned a statistically significant t-value (6.20, $df=71$, $p=.000$).

General ability in constructing the pie chart

In the initial task almost all (93.1%, n=67) of the students were able to show that they were generally able to construct a pie chart from raw data, even though some of them may have made calculation errors along the way. (However all had to show that they had followed the appropriate formula for dividing the pie into the various segments.)

In the transfer task this figure dropped to 66.6 per cent with just under a third of those who demonstrated this general ability in the initial task doing so in the transfer task. One student who was not able to perform the task during the initial task was able to perform it in the transfer task. A better view is presented in table 30.

Table 30: Ability to transfer skills between contexts—number of students

	Able to transfer	Not able to transfer	Totals
Initial task Not able to draw pie chart	1	4	5
Initial task Able to draw pie chart	47	20	**67**
Totals	**48**	**24**	**72**

Recalling the general concept

The work of students was examined to discover whether or not they had recalled the concept of what a pie chart generally looked like. Regardless of their ability to perform the technical aspects of calculating degrees and percentages, or measuring the segments of the pie chart, the overwhelming majority (95.8%, n=69) of students, showed that they knew that a pie chart was a circular shape rather than a bar, column or line graph. In addition well over three-quarters of these students (84.1%, n=58) were able to recall this in the transfer task.

Male and female performance comparisons

There were 31 males and 41 females in the study. All but one of the males and all but four of the females were judged as being generally able to construct a pie chart in the initial task. In the transfer task this figure dropped substantially. Here almost a third of the males and a quarter of the females were not able to do so. Table 31 presents a matrix showing the occurrence of transfer across the two groups.

Table 31: Performance of males and females in constructing pie charts in initial and transfer tasks—number of students

	Able to transfer		Not able to transfer		Totals
	Males	Females	Males	Females	
Initial task					
Not able to draw pie chart	1 (2.2%)	0	0	4 (9.8%)	5
Initial task					
Able to draw pie chart	20 (64.5%)	27 (65.9%)	10 (32.3%)	10 (24.4%)	**67**
Totals	**21**	**27**	**10**	**14**	**72**

Means and standard deviations obtained in all scored components and for the aggregated scores were computed. These are reported in table 32.

Table 32: Means and standard deviations (in parentheses) for scores obtained in all components by males and females

Components	**Initial task**		**Transfer task**	
	Males	Females	Males	Females
Collecting information	17.2 (sd 3.3)	16.2 (sd 5.1)	13.2 (sd 3.4)	13.3 (sd 3.5)
Analysing information	8.7 (sd 2.0)	8.3 (sd 3.0)	5.7 (sd 4.4)	6.4 (sd 4.5)
Producing the formula	4.0 (sd 0.0)	3.7 (sd 1.1)	2.5 (sd 1.9)	2.6 (sd 1.9)
Computing the degrees	17.6 (sd 3.9)	17.4 (sd 5.9)	11.9 (sd 9.4)	12.9 (sd 9.5)
Constructing the pie chart	16.1 (sd 6.6)	14.7 (sd 7.4)	11.4 (sd 9.4)	11.0 (sd 8.8)
Combining the components	63.9 (sd 10.4)	61.2 (sd 16.5)	44.9 (sd 25.3)	46.6 (sd 24.7)

A Kruskal-Wallis one-way analysis of variance for ranks test was computed for each component. The results showed that when scores were used there were no statistically significant differences at the .01 level of significance between the results of males and females.

Performance across teacher-defined achievement groups

Teacher ratings of student achievement divided students into four groups. Just over a tenth (15.3%, n=11) comprised the *below average* group. Almost double this number (25.0%, n=18) comprised the *average* group. About a third (31.9%, n=23) comprised the *good* group, and just over a quarter (26.4%, n=19) comprised the *advanced* group. (One student was not included in the ratings.) Data on the average and standard deviation scores obtained by each group appears in table 33.

Table 33: Means and standard deviations (in parentheses) for each component across achievement groups*

	Group 1 (below average)		Group 2 (average)		(Group 3 (good)		Group 4 (advanced)	
	Initial task	Transfer task	Initial task	Transfer task	Initial task	Transfer task	Initial task	Transfer task
Collecting information	15.9 (sd 6.2)	12.3 (sd 4.4)	15.0 (sd 5.7)	13.4 (sd 4.0)	17.2 (sd 3.6)	13.5 (sd 2.9)	18.0 (sd 1.7)	13.5 (sd 3.1)
Analysing information	7.8 (sd 3.3)	4.0 (sd 4.7)	8.4 (sd 2.8)	6.6 (sd 4.3)	8.4 (sd 2.7)	5.9 (sd 4.6)	9.3 (sd 1.7)	7.4 (sd 4.0)
Producing the formula	3.6 (sd 1.2)	1.8 (sd 2.1)	3.8 (sd 0.9)	2.9 (sd 1.8)	3.8 (sd 0.8)	2.5 (sd 2.0)	4.0 (sd 0.0)	3.1 (sd 1.7)
Computing the degrees	13.6 (sd 9.0)	9.0 (sd 10.3)	18.1 (sd 4.7)	13.8 (sd 8.9)	17.7 (sd 4.4)	11.8 (sd 9.4)	18.7 (sd 1.9)	14.7 (sd 9.0)
Constructing the pie chart	10.5 (sd 9.6)	6.9 (sd 9.7)	15.9 (sd 6.2)	10.7 (sd 8.1)	14.0 (sd 6.9)	11.9 (sd 9.4)	19.8 (sd 0.9)	13.6 (sd 8.8)
Combining components	51.9 (sd 21.5)	34.0 (sd 25.1)	62.2 (sd 14.1)	47.6 (sd 22.8)	61.7 (sd 12.0)	45.8 (sd 25.3)	70.7 (sd 4.9)	52.7 (sd 24.6)

*Teacher-identified achievement groups: Groups 1–4

Table 34: Mean ranks for each component across achievement groups*

	Group 1 (below average)		Group 2 (average)		Group 3 (good)		Group 4 (advanced)	
	Initial task	Transfer task	Initial task	Transfer task	Initial task	Transfer task	Initial task	Transfer task
Collecting information	39.2	31.3	29.0	37.8	36.4	35.5	40.0	37.6
Analysing information	31.3	25.7	35.6	36.5	34.9	36.0	40.1	41.4
Applying the formula	34.3	28.6	35.5	38.4	36.0	34.7	37.5	39.6
Computing the degrees	30.1	30.0	38.9	36.6	34.1	32.8	38.7	42.8
Constructing the pie chart	25.5	27.0	36.1	32.1	29.8	38.2	49.6	42.3
Combining components	25.0	26.3	34.7	34.1	30.8	36.0	49.9	43.3

*Teacher-identified achievement groups: Groups 1–4

A Kruskal-Wallis one-way analysis of variance for ranks test was computed to examine differences between the groups for initial and transfer tasks. These showed that in the initial task, differences between the groups were at the .01 level for constructing the pie chart and combining the components. There were no other statistically significant differences.

A breakdown of the mean ranks for each of the components appears in table 34.

Transfer strategies reported by successful and unsuccessful students

All students were asked to respond to questions about the strategies they had employed to perform the transfer task. The responses of the students who had been successful in both the initial task and the transfer task and the students who had been successful in the initial task and unsuccessful in the transfer task were analysed separately.

Almost all (95.8%) of the students in the group reported that they had learned how to do a pie chart in the mathematics class. The remainder failed to provide an answer to this question.

When they were asked how they knew what to do the overwhelming majority replied that their teachers had taught them. A breakdown of their responses to this question appears in table 35.

Table 35: Strategies reported by students in answer to the question: *How did you know what to do?*—number of students

Strategy	Successful students	Unsuccessful students
Teacher taught me/I was taught	24	16
I practised exercises	2	0
I learnt what to do/ learnt it step by step	1	1
I learnt from teacher and from examples/exercises/practice	9	1
I knew from the test we had done	1	0

Students were also asked to report how they knew what they had to do to draw a pie chart in the transfer task. By far the most common response received from successful students was that they had remembered what to do. There were no major trends in the responses of unsuccessful students. Responses to this question appear in table 36.

In response to the question asking them to report the first thing they had remembered to do students provided a variety of responses. These are reported in table 37.

Students were then asked whether or not they knew the formula for working out parts of the pie chart. Their responses appear in table 38.

Table 36: Strategies reported by students in response to question: *How did you know what you had to do to draw a pie chart today?*—number of students

Strategy	Successful students	Unsuccessful students
Remembered	29	5
Learnt how to do it	4	2
Instructions	4	1
Was taught	2	0
Did not know what to do	0	3
Count then draw table	1	0
Guessed	1	0
Remembered and guessed	1	0
Revised pie charts	1	0
Forgot	0	2
Knew it	0	2
From maths class	0	2

Table 37: Student responses to question: *How did you know what to do first?* —number of students

Response	Successful students	Unsuccessful students
Count	8	0
Calculate percentage	7	1
Convert percentages to degrees	5	2
Draw table	5	2
Tally data	5	2
Collect data	5	0
Count then set up table	3	0
Sort and categorise data	2	0
Draw circle	1	4
Multiply by 100 then by 3.6	1	2
Chart	1	1
Fractions	1	0
Work it out	1	0
Can't remember	0	1
Divide by total	0	1

Table 38: Student responses to question: *Did you know the formula for working out parts of the pie chart?*—number of students

Response	Successful students	Unsuccessful students
Yes I knew the formula	41	6
Did not know the formula	0	2
Forgot the formula	0	3
Sort of knew the formula	0	1

They were then asked to report how they knew the formula to be used. By far the most common response for successful students was that they had remembered how to do it. Table 39 presents the data on student responses to this question.

Table 39: Student responses to question: *How did you know the formula?*—number of students

Response	Successful students	Unsuccessful students
Remembered it	24	2
Was taught it	15	4
Did not know the formula	0	2
Learnt it	1	1
I used a calculator	1	0
From maths	1	0
Worked it out	1	0
From teacher	0	2
Can't remember	0	1

Students were also asked what part of the formula they thought was hardest to remember. Their responses are provided in table 40.

Table 40: Student responses to question: *What part of the formula do you think is the hardest to remember?*—number of students

Response	Successful students	Unsuccessful students
None	11	3
Compute percentages	7	0
Multiply by 100 and then by 3.6	6	0
Convert percentages to degrees	5	1
Divide by total	2	0
Divide by total number and then multiply	1	0
Had no problems	1	0
Using the protractor	1	0
All	0	2
Don't know	0	3
To compute the degrees	0	2
The mathematical part	0	1
To count properly	0	1
The formula	0	1

Table 41: Student responses to question: *How would you teach a friend to use pie charting skills learned in mathematics to solve a pie chart problem in English?*—number of students

Response	Successful students	Unsuccessful students
Same way	25	6
Teach formula	4	0
Don't know	2	1
Teach them the way I remembered it	2	0
Explain it	1	2
Teach formula and use examples	1	1
Apply skills to English	1	0
Convert the data	1	0
Count the things first	1	0
Give examples and answer questions	1	0
Same way but read data carefully	1	0
Step by step	1	0
Can't teach them	0	3
Show them how to do it	0	1

When students were asked about how they would go about teaching a friend to use pie chart skills learned in mathematics to solve pie chart problems in English, their most frequent response was that they would teach friends to use the same processes as had been used in the mathematics class. Responses provided by both types of student appear in table 41.

Students who experienced difficulties and could not do the task were asked for reasons as to why they could not do the task. Table 42 presents their responses.

Table 42: Reasons for being unable to complete the task reported by unsuccessful students

Reason	No. of students
Forgot	5
Can't remember	4
Forgot the formula	3
Did not count properly	2
Was not thinking	1
Degrees calculated were too big	1
Could not work out percentages	1
Could not work out percentages to degrees	1

In conclusion students were asked to give reasons for why some people were able to construct a pie chart in a mathematics context and also able to do so in an English context while others could only perform the task in a mathematics context. Table 43 details the responses of successful and unsuccessful students to this question.

Table 43: Student responses to question: *Why do you think some people were able to construct a pie chart in maths and could also do it in English, and others could only do it in maths?*—number of students

Response	Successful students	Unsuccessful students
Forgot/can't remember it	8	2
Don't know/not sure	6	3
Same process	5	2
Were confused	3	1
They don't apply their skills	3	1
Data not numeric in English	3	0
Long time since they did it	2	1
Different data	2	0
Different atmosphere	1	1
Don't realise it is the same	1	0
Apply skills to English	1	0
Deals with different problems	1	0
Did not know how to gather data	1	0
Learnt it before the test in maths	1	0
Did not read data properly	1	0
Think differently in maths to English	1	0
Had better understanding	1	0
Don't learn from mistakes	1	0
Had better teachers	0	1
It is easier in maths	0	1
No teacher to ask to help them in English	0	1
The skill was taught in maths	0	1
Worded question in English	0	1
They think it is a different process	0	1

Overview of findings

The findings of this study support the findings of Study 1 which show that although transfer of skills and knowledge across contexts may occur, it is by no means guaranteed in every case. The study also shows that transfer of accurate performance is also not guaranteed and in some cases it is very infrequent. This is particularly so in the information collecting stages of both initial and transfer tasks. In addition the proportion of students able to perform at the 100 per cent level of accuracy in both tasks varied for various components. It ranged from just under a third in analysing the information, to just under a half in computing the degrees, and constructing the pie chart, and to well over a half in producing the formula. However when lower levels of accuracy are accepted, the number of students who were judged to be generally able to construct a pie chart from raw data in both tasks tended to rise. This provides some evidence to support the occurrence of the partial transfer of complex skills.

Almost all students were able to recall the general concept of what a pie chart generally looked like in the initial task with about three-quarters of these being able to recall the concept in the transfer task. These findings are equally true for females and males. They are also generally true for students of the different achievement level groupings.

Discussion and conclusions

Overview

It is evident from the results of Study 1 and Study 2 that there is no guarantee that being able to perform a skill in one context always means being able to transfer the skill to another context. This is equally true for boys and girls. However, it is also evident that the level of proficiency at which a skill is acquired in the first place will have a major bearing on how well it transfers to a new context. Most students performed at lower levels of accuracy on the major components of the transfer task than they had done in the initial task. However those students who were able to construct the pie chart to higher levels of accuracy in the initial task were more likely to do better in the transfer task than those who had not initially performed at a high level of accuracy.

In addition the study has found that students with a higher mathematics achievement level as defined by their mathematics teachers are more likely to be able to transfer the skill to a new context than are those of lower achievement. This is something teachers have always known. However, because substantial numbers of those with higher achievement levels also found it difficult to transfer the skill to the new context, we can claim that achievement level in mathematics on its own is no guarantee of transfer. In addition teachers have always maintained that those students who are better at performing skills in the classroom will generally be better able to perform similar skills in an exam or outside the classroom.

Skill acquisition improves transfer

Another major finding in this study is that transfer can generally occur if the skill has been learnt to a proficient level in the first place. That is, transfer is facilitated by better skill acquisition. This is a heartening finding for teachers and trainers. Not only does it confirm the long-held view that training is not completely in vain but it can give them renewed optimism and hope that they can make a difference to student learning and to student ability to transfer. The findings also give increased hope to those who believe that generic skills like using 'mathematical techniques' are not only the preserve of the intelligent, but that those of less ability can also be taught skills which hopefully can endure over time and can be applied to different contexts. However we must not lose sight of the role played by context-specific knowledge and the knowledge that has been accumulated over time. These may also hold the important key to understanding transfer.

Spontaneous transfer

This study did not set out to examine the occurrence of spontaneous transfer. That is, transfer which happens without any prompting to help students retrieve previous learning. Instructions in both initial and transfer tasks asked students to use a pie chart to demonstrate differences in their data. These instructions set the ground rules for the skill to be used. The instructions, however, did not ask students to use a formal tallying process for counting purposes. Nor did they ask students to order the data to better organise it for accuracy and precision, or to label the pie chart in any way. It is interesting to note, therefore, that in Study 1 very few students used these orderly and systematic approaches to organising information in the initial task and of these even fewer used these approaches again in the transfer task. Although more students in Study 2 used these organising processes in the initial task than had done so in Study 1, few of these remembered to use these in the transfer task.

These results suggest that students may not always make connections between contexts that will help them solve new problems in ways they have used in the past to solve similar problems. If students are not making these connections between contexts then this has definite consequences for training and learning. It highlights the need for teachers and trainers to help students make the right and relevant connections between current tasks and previous knowledge. It also means that they may need to establish with students the relevance of what they are teaching at the time of teaching so that students will be able to connect future activities with present learning.

Although these figures show that the occurrence of spontaneous transfer in the transfer task was infrequent, one could also argue that it occurred more readily in the initial task. That is that students had transferred what they had learnt during mathematics training to the mathematics test. However one also needs to ask why this knowledge or skill does not persist for a longer period of time so that it is naturally applied to a transfer task. One reason may be that students may not feel that graphing activities are important in a context other than mathematics and so do not retrieve this information when they are asked to do so in these contexts.

Strategies used in transfer

It is evident from student responses to interview questions and questionnaire items that apart from remembering what they had learnt in mathematics, successful students were not able to explain how they were able to transfer the skills they had learnt to the new context. This is also the case with experts in other fields who have been found to find it difficult to describe in detail exactly how it is that they are able to do a certain task. If transfer is dependent on the ability to retrieve information from prior learning, it makes it doubly important for students to be able to practise a skill until they are so proficient at it that it can be easily accessed when it is required. The ability to transfer may also be linked to the amount of knowledge stored and the inter-relationships that exist between various components of this knowledge.

Although there were no major trends in the initial steps taken by successful and unsuccessful students in performing the transfer task, successful students were more likely than unsuccessful students to report strategies which were more likely to put them on the path to coming up with the right solutions. Successful students also reported strategies which would assist them to arrive at the correct answers for each component of the problem. The unsuccessful students were more likely to report mistakes such as using the wrong formula, and faulty logic. This also supports findings which claim that non-experts look at surface features while experts look at fundamental concepts.

The importance of teacher input

The responses of successful and unsuccessful students highlighted the role of the teacher in transmitting skills. This further underscores the responsibilities that teachers have for the delivery of training, the acquisition of skills by students, and the subsequent transfer of these skills by students to new contexts. If teachers are perceived by students to be influential in their acquisition of skills, then it is important that they provide appropriate learning environments in which students can learn, develop and practise skills. In this way they can make sure that the skill has been acquired to a proficient level in the first place so that it can be better remembered when it is required at a subsequent date.

Varying levels of accuracy

As previously noted the transfer of performance at the 100 per cent level of accuracy was infrequent. This is especially the case with respect to precision in collecting information. Very few students were able to perform at the 100 per cent level of accuracy in collecting information in the transfer task. In fact only three students out of the total group were able to do so with only one of these having shown an ability to be 100 per cent accurate in both tasks. We cannot take this to mean that the ability to collect information does not transfer across contexts, for students were able to follow the general schema for counting items in a particular group. But it may mean that accuracy skills taught in mathematics may not transfer as easily to other contexts.

Students were better able to transfer the accuracy skills demonstrated in the mathematics context in the latter components of the task. However we must also keep in mind that students were able to gain the full marks for these components even if they had made a counting error in the data gathering stage.

When lower levels of accuracy are accepted we find that the ability of students to transfer these skills across contexts improves markedly. This may be an example of components or parts of skills transferring to other contexts more readily than others.

Why students may perform better in initial tasks than in transfer tasks

There may be a number of reasons for students performing better in the initial task than in the transfer task. Teachers may have made a special effort to ensure students were well prepared for the first test by providing extensive revision of the processes for constructing pie charts immediately before the day of the test. Another explanation for the better performance in the initial task is that as teachers administered the initial task they may have unwittingly provided subtle clues to students about the task during the test. Furthermore the initial task took place in the mathematics context which is the natural domain for graphing skills. This may have also been a factor in improving students' ability to remember the skill, and the conventions for pie charts which must be respected (titles, angles, percentage labels etc.) in the initial task.

Alternatively students may have been less able to do the transfer task because it took place about one month after the initial task. This time lag may have affected whether or not students had stored knowledge in long-term memory and how much of this they were able to retrieve when the next test took place. In addition the conventions used in mathematics may not have been seen as important in the social science or English context. This may also have affected their transporting of rules expected for solving problems in mathematics to another context.

The findings that better skills acquisition promotes transfer is encouraging to educators and to workplace trainers. This means that they can be confident that although training will not guarantee transfer, there is a greater likelihood that skills which have been learnt in one context can transfer to different contexts if they have been well developed in the first place.

Gender makes no difference to transfer

The findings of this study also show that the ability to transfer skills and knowledge from one context to another does not divide along gender lines. This is supported by evidence of no statistically significant differences between the performance of males and females across all components in both tasks in both studies. There is no reason why we should expect that females and males would transfer skills that have already been acquired at a differential rate. Therefore these findings are not surprising.

Learning retention is a pre-condition for transfer

Retention of learning is necessarily involved in transferring strategies to solve problems in new contexts. This study has confirmed that it is a necessary pre-condition for being able to apply learning at a future date and in another context. One factor which may help students improve their retention of learning is to ensure that the skill is firmly embedded in the first place. That is, that they are given the opportunity to practise the skill correctly over and over again so that it becomes automatic and can be retrieved at a later date. It is interesting to note that when the successful students were asked how they had known what to do the great majority reported that they had remembered the skills from teacher explanations and demonstrations in mathematics classes. This supports Gick and Holyoak's findings on the importance in transfer of perceived similarity between tasks.

The findings also suggest that there were few retention problems with the basic procedures of collecting, organising and analysing the information. There were few decreases in performance in the basic procedures in the transfer task. However, this may have been due to the fact that collecting and analysing information in the transfer task were more straightforward than in the initial task. Other explanations could be that:

- counting cases and analysing information at a low level seems to be a skill which transfers easily between contexts
- the instructions that are given involve little need to transport skills between students picking up cues from contexts
- observing what other students seem to be doing may provide subtle clues to uncertain students

The strategies used by successful students in transferring skills across contexts provide another indication of the importance of retention of past learning in transfer. This is demonstrated by the responses of successful students to the question asking them to report how they knew what they had to do to draw a pie chart in the transfer task. Almost three-quarters of the successful students reported that they had remembered or been taught the skills that were required. A similar pattern is repeated when students were asked to report how they knew the formula to be used in solving the problem in the transfer task.

This study provides further evidence for the influence of adequate and proficient student learning on the ability to transfer skills and knowledge across contexts. Students who could demonstrate that they had acquired the skills to a high level in the initial task were more likely to be able to apply these skills in the transfer context. In contrast those who demonstrated a low level of skills acquisition in the initial task were also more likely to demonstrate low levels of skills acquisition in the transfer task. These findings make a strong case for supporting theories which posit learning to be a sub-component of transfer.

Level of achievement makes little difference

In Study 1 the two highest achievement level groups outperformed the two lowest achievement level groups in all components of the initial task. However there were only significant differences between the advanced group and the below average group in applying the formula, constructing the pie chart and combining the components in the transfer task.

In Study 2 there were only two cases where there were major significant differences between the performance of students of different achievement levels. One case was in constructing the pie chart where the advanced group performed significantly better than did the good group and the below average group. The other was across all components in the initial task where the advanced group once again performed better than the below average group.

One reason for there being so few statistically significant differences between the four groups on many of the components of both tasks in Study 2 may have been due to the groups being closer to each other in achievement level than was initially thought by teachers. Another reason may have been that the level of proficiency in drawing pie charts for students did not differ greatly.

Implications for vocational education and training

There are many implications for vocational education and training which result from this study. Firstly, they support the need to revisit strategies for improving training processes to ensure that learning occurs. Secondly, they support the need to review approaches to competency-based training and the application of recognition of prior learning and credit transfer processes.

Increasing proficiency in skill development

The findings of this study support the importance of initial learning and skill acquisition in the transfer of skill to different contexts. This means that if we wish skills acquired in training to transfer to other settings we must make sure that the skills have been acquired to a proficient level in the first place and that students are given the experience and practice required to get them to this level. This may require a restructuring of the time required to complete the units of competency within modules.

The findings also suggest that ability on its own is not a guarantee of transfer. It is because of this that teachers must make sure that students of lower ability are given the extra attention and practice required to develop skills to a proficient level so that these skills will endure with the passage of time and be available to be applied to new contexts.

Reviewing approaches to competency-based training

This study has shown that apart from a few cases, demonstration of a skill in one context is no guarantee of being able to repeat the skill to the same level in another context. If this is true for all skills, it argues against relying on a single demonstration of competence to reflect the achievement of a competency standard in the classroom or the achievement of a competency standard in the workplace. Furthermore, if it is true that students may lose a considerable amount of what they first learn in one context when they transfer the learning to another context, then there is a case for reviewing the way that competency-based training and assessment is applied. What the findings of this study suggest is that there is a definite need for knowledge and skills acquired in modules to be revisited through review, reflection and practice well after the module has been completed to ensure that the knowledge has endured.

Reviewing approaches to recognition of prior learning and credit transfer

These findings have also highlighted issues that should be of concern to administrators of credit transfer and recognition of prior learning (RPL) processes. If there is no guarantee that the knowledge and skills of students requesting RPL for past experience have endured, even though there is evidence that such knowledge and skills existed at some time, then additional safeguards need to be established to ensure that RPL or credit transfer is deserved. Such safeguards may include providing opportunities for applicants to refresh such knowledge or skills by attending brief review sessions where major principles and knowledge which underpin the skills are revisited.

Suggestions for further research

These findings suggest that proficiency improves transfer between contexts. What would also be of value is an examination of the extent to which the events which surround the initial acquisition of skills have a major bearing on how or if they are applied at a later date.

In the vocational education and training sector it would also be of value to find out whether or not those students who have been granted exemptions based on evidence of RPL perform at the same level in related subjects as those students who have not been granted RPL but have completed the same subjects.

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