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Introduction

Transfer can be defined as 'the degree to which behaviour will be repeated in a new situation' (Detterman and Sternberg, 1993, p. 4). Thus transfer of learning occurs when learning in one context or with one set of materials impacts on performance in another context or with related material. Pennington and Rehder (1995) borrowing from Larkin (1989) also define transfer as the use of knowledge or skill acquired in one situation in the performance of a new, novel task, a task sufficiently novel that it involves additional learning as well as the use of old knowledge. Research evidence as to whether or not transfer occurs is rather ambivalent. On one hand some research indicate that there is no transfer and that even if there is, it is rather through manipulation of one sort or the other: subjects are told what to do. Detterman (1993) makes two important conclusions: a) Spontaneous transfer is very rare; b) those studies claiming to show transfer can only be said to have found transfer by the most generous of criteria and would not meet the classical definition of transfer. (ibid: 13-15).

On the other hand, other research findings claim that transfer does occur, such as Novick (1990), Brown and Kane (1988), Gick and Holyoak (1980). Detterman (1993) refutes these claims and makes a strong case against these studies and says:

'The amazing thing about all these studies is not that they do not produce transfer. The surprise is the extent of similarity it is possible to have between two problems without subjects realising that the two situations are identical and require the same solution. Evidently, the only way to get subjects to see the similarity is to tell them or to point it out in not so-subtle way. The experimental manipulations used in these studies remind me of the field hand who had an uncooperative mule who refused to budge despite his intense urging' (p. 13).

Thus research evidence on transfer seems to suggest strongly that transfer is very rare. If this is the case, what are those factors that one would have to look out for to enhance transfer? Can instruction be manipulated to foster transfer? These are the questions that we investigate. Our hypothesis is that transfer does not occur just because we want it to happen. This notwithstanding, teaching can be manipulated to foster students' generalisation and conceptual restructuring by paying attention to some determining factors that can enhance transfer. Our methodology of testing the hypothesis is purely theoretical: it is an examination of reviews and empirical evidence from research work on the topic.

Consequently, this article looks at the following: a) those determining factors of transfer; b) how to use these factors as building blocks to teach in such a way that teaching aims to teach information in a multiple of contexts through 'hugging' and 'bridging' method so as to enhance transfer and conceptual restructuring.

There are at least five fundamental determining factors in the psychological literature that seem to enhance transfer. These factors are not automatic in learning and have to be fostered in the teaching-learning process if we want transfer to be enhanced. They are:

- Structure of the training transfer task
- Depth of encoding
- Roles of abstract training
- Strategic variation in learning
- Impact of background knowledge

The implication is that in teaching-learning we need to show students how to apply knowledge in a variety of ways, such as: (1) teaching so as to make knowledge more retrievable later on. Perkins (1988) calls this presenting 'knowledge as design'; (2) helping students to organise information in a way that will facilitate transfer; (3) helping students to make discrimination that they will need later on; (4) the teacher establishing a mind set for transfer, that is teaching in such a way that knowledge will not be separated from each other (i.e. the "bridging" method). In so doing, knowledge must be perceived not simply as information to be remembered, but more especially to see knowledge as design in which it could be de-contextualised and abstracted to different levels of contexts.

Determining Factors of Transfer

There are varieties of factors that are critical in determining transfer. We examine five of such factors in this section.

Structure of the training and transfer task

One of the most important determining factors of transfer is certainly that of the ability of the subject to induce rules that characterise a category of tasks. What is learned from training, and hence the knowledge potential available for transfer, is constrained by the structure of the task itself. Often it is possible to develop a set of rules that classifies the items of training and transfer tasks as members of a common category. This is the whole principle of perceived similarity. If so, then the learning of these rules will be an efficient means of ensuring positive transfer. A typical case is in verbal learning. For example, in category-learning task, classification during transfer could proceed on the basis of whether the instance satisfied the relevant rules. In the same way, solving a new problem of a known type would involve having to classify the new problems belonging to a previously learned problem category, followed by implementation of appropriate solution procedures.

On the other hand, when one is dealing with a complex task, it may not be easy to learn a rule cluster or schema for a category. Rule induction is influenced by the complexity of the possible rules, as well as by the availability of other successful strategies not requiring rule acquisition. Thus, for example, it is

difficult to demonstrate transfer between instances of a category of problems defined by a complex rule if the problems can be solved more easily by trial and error than by learning rules (Sweller, 1980 cited in Cormier & Hagman p.21)

If a category can be described by a simple rule, then a strategy of explicit hypothesis testing is likely to succeed in identifying the appropriate rule. In other words, once we can identify a rule that characterises a category, we can on the basis of that rule induce generalisation. Let us take as an example. Suppose we were presented with a series of letter strings: ABC, AABBCC, and AAABBBCCC. We would surely notice that the strings can be described by a rule such as "If the string consists of some number of A's followed by the same number of B's followed by the same number of C's, then it is a legal string."

Pennington and Rehder (1995) have done detailed studies in this area. They call it the componential view of transfer. Their claim is this: that the study of transfer is complicated by the fact that any training task consists of multiple performance components, and that each component can contribute independently (and either positively or negatively) to the transfer task (ibid: p. 231). Whether training yields a net advantage or net disadvantage depends on the relative contribution from each component. The point being made here is that the structure and complexity of the training task can contribute to determine either transfer or interference.

Thus the claim being made by Pennington and Rehder (1995) as far as task component is concerned is that whether the stimulus differentiation, response learning, and association learning that took place during the first list of paired-associates influences the learning of a second list depends on the relative contents of the lists (ibid. P.232). In short the structure of the task itself determines the optimal learning strategy for subsequent transfer.

Depth of Encoding

In 1973, Donald Thompson and Tulving proposed the encoding specificity principle asserting that "only that can be retrieved that has been stored, and that how it can be retrieved depends on how it was stored" (Tulving and Thompson, 1973, p.359). In a more elaborate term, it means that 'specific encoding operations performed on what is perceived determine what is stored and what is stored determines what retrieval cues are effective in providing access to what is stored' (p.369). Thus, the principle makes explicit the dependence of memory trace on the encoding operation, and hence the relation or interaction between encoding and retrieval condition.

According to Tulving the following define the essence of the notion of encoding specificity: a) the necessity or importance of stipulating both encoding and retrieval condition when describing data or making theoretical inferences from them; b) the futility of trying to understand the processes involved in remembering either, in general or in any specific situation, in terms of only the encoding or the storage processes or only in terms of retrieval processes and; c) the essential role played by the phenomenon demonstrating interactions between encoding and retrieval conditions in shaping theoretical ideas about memory (Cermak & Craik, 1979, p. 407-408). There are some critical aspects of this principle of the depth of encoding that are considered to be crucial in either promoting positive transfer or negative transfer. Two of them are: *encoding specificity and levels of processing* and *encoding /retrieval Interaction based on Compatibility.*

a) Encoding Specificity and Levels of Processing

The essence of the set of ideas known as "levels of processing" with respect to encoding is that memory is a by-product of perception. Therefore the goodness of storage or retention of information of a learned item depends on the conditions under which it was studied. Craik and Lockhart in 1972 (cited by Cermak and Craik, 1979) for example proposed that the durability of the memory is determined by the depth or level at which stimulus items are processed: 'Trace persistence is a function of depth of analysis, with deeper levels of analysis associated with more elaborate, longer lasting and stronger traces' (p. 675)

b)Encoding/Retrieval Interaction based on Compatibility and depth of encoding

The main point here is that considerable range of experimental conditions and empirical facts show that the remembering of events is determined by the interaction between encoding and retrieval; the concordant retrieval conclusion holds that success of recollection of an event depends on the congruence or compatibility between trace information and retrieval. (Cermak and Craik, 1979, p. 417). Thus the basic assumption here is that the recollection of an event is always determined by the compatibility relations between encoding and retrieval condition. Hence compatibility is a critical determinant factor of recollection.

Roles Of Abstract Training And Examples

The fundamental question in this section is this: When a schema or rule sufficient to perform a task is directly given to the learner, is it sufficient for transfer, or inclusion of examples is necessary? Research indicates that examples aid transfer. Nitsch (1977) found that subjects who learnt only the abstract definitions of novel words performed less well on transfer tasks than did subjects who received examples along with the definition. Similarly, Gick and Holyoak (1983) found that a verbal or spatial summary of a solution schema did not facilitate transfer to a target problem, unless it was accompanied by two examples.

Finally, studies of logic training have revealed that subjects trained on an abstract description of conditional reasoning do not adequately transfer this knowledge to test problem unless illustrative examples are included during training (Cheng, Holyoak, Nisbett, and Oliver, 1986). Example appear to be important in showing how an abstract concept can be instantiated, even when rules are directly presented during training, especially if the concept is not part of the intuitive repertoire of the learner.

Other work has shown however, that people sometimes derive considerable benefits from abstract training even when only minimal examples are provided (cited by Gick and Holyoak 1987). In general, an abstract rule or schema included with the acquisition instances may facilitate transfer to novel examples, especially when the acquisition and transfer are superficially dissimilar (Gick and Holyoak, 1983) or when the rule is difficult to induce from rule alone.

Strategic Variations In Learning

Instructions can affect processing strategies employed during acquisition. This in turn can influence both learning and transfer. Instructional variations that can effect strategies have also been employed in studies of problem-solving. For example, sweller, Mawer and Howe (1982) that the use of "means-

ends" (that is a general method for decomposing problems and trying to solve them by working backward from the stated goal) facilitated initial problem-solving. It is possible to influence the use of means-ends strategies and consequent learning and transfer performance by suitable instructional manipulations. Several studies demonstrate this (cf.Mawer and Sweller, 1982; Owen and Sweller, 1985; Sweller and Levine, 1982; Sweller, Mawer, and Ward 1983).

Several important ideas emerge from this review of research on the relationship between training task and subsequent transfer. Manipulations that foster acquisition of generalised rules, sufficiently abstract as to characterise both the training and the subsequent transfer task, will increase positive transfer. Direct abstract training in rules embodying appropriate solution procedures is likely to be useful, but rules for classifying novel instances into the category must also be acquired to ensure successful transfer. Unless such rules for classification have been acquired earlier, it will be necessary to augment training in abstract rules with exposure to concrete examples. (cf. Pennington and Rehder, 1995). Thus knowledge represented at a more abstract level should transfer "farther" across more diverse situations (Pennigton and Rehder, 1995, p. 267).

The Roles of Background Knowledge in Transfer

The background knowledge of subjects is another determining factor for subsequent transfer. We want to make two important observations regarding the role of background knowledge as evidenced by research studies. The most common assumption is that memory is strongly affected by the relations between inputs and the knowledge or the skill currently available to the learner. However, we intend to observe that this point is not the same as the view that assumes that the appropriate knowledge permits deeper, more semantic levels of processing. Thus, from the present perceptive 'semantic' vs. 'nonsemantic' is different from the problem of input-knowledge compatibility. In short, the utilisation of past knowledge to make inputs *meaningful is* not equivalent to processing their semantic meanings (Cermak and Craik p.340).

The advantage of this distinction between input-knowledge relationship and that of "semanticity" of acquisition processing, lies in the fact that it discourages the assumption that that the latter is sufficient to explain memory performance. In the same token it is not sufficient to simply assume that memory is a function of the compatibility of input knowledge relationship. An adequate theory of knowledge must explain how relevant knowledge (be it semantic or non semantic) can facilitate one's ability to perform subsequent acts of knowing and remembering. A good theory must also acknowledge that the value of a particular acquisition activity is relative to a particular testing context.

Thus the point being emphasised here is the fact that background knowledge per se be it the semantic-nonsemantic metaphor or the compatibility model alone will not be sufficient to explain the role of previous knowledge in transfer. It is the combination of both that can effect transfer.

IMPLICATIONS FOR TEACHING TO FOSTER GENERALISATION AND CONCEPTUAL RESTRCUTURING

In this final section, our primary concern is to look at the practical implications that these determining factors of transfer have for instruction. To what extent can our knowledge of theories of learning and transfer effectively be applied in teaching-learning processes so as to promote significant, meaningful learning? The claim being made in this article is this: transfer is not spontaneous (cf. Detterman and

Sternberg, 1993, p.35). Instruction has to be designed in such a way as to make transfer more likely to occur.

The teacher needs to teach information in a way that will make it more flexibly retrievable later on. The best way to accomplish this goal is first, explicitly show students how they can apply information they have learned in a variety of contexts, and then to require of students that they find applications themselves.

Second, teachers need to help students organise information in such a way as to facilitate transfer. A disorganised presentation of information has two side effects: it impedes immediate learning and secondly, it impedes students' ability later on to transfer what information they have learnt. Bransford and Johnson (1972, 1973) have demonstrated that the understanding of a story was remarkable facilitated by subjects being given a framework (in their case, a story title or picture caption) within which to organise information from the story. Scripts theory (Shank and Abelson, 1977) makes the same point. It is the responsibility of teachers, not students, to organise information presented in a course. Mayer and Greeno (1972) explain that the organisation of materials should be both internally and externally connected. Thus the various pieces to be learnt should make sense in terms of each other and in terms of other information that the students have about the world. Such connections are often not drawn.

The third implication that could be drawn from our theoretical discussions for effective teaching that will promote transfer is helping students to make discrimination that they will later need. An excellent example of discriminatory learning is on the teaching of statistics. Students learn the assumptions underlying statistical tests so that they will know when the tests are applicable and when they are not.

The fourth and perhaps the most important implication is that teachers need to establish a mental framework for transfer. Thus the way, in which academic subjects are typically isolated from each other, and from any real world use, do not encourage a mental set for transfer. For example, one of the best things to do in teaching would be to teach and then test knowledge for *use* rather than for its own sake. In other words, if students were directly shown how to use what they learn and then were tested in their ability to use rather than simply recall of information, they would begin to acquire the mental set needed for transfer.

In this final section therefore, we would be looking at two main techniques of teaching that foster transfer, generalisation and conceptual restructuring: (1) how to teach information in a multiple of contexts through "hugging" and "bridging" method, and (2) methods for establishing a mental framework for transfer.

Teaching information in a multiple of context through "hugging" and "bridging" Method

In broad terms, we can speak of two techniques for promoting transfer in teaching: "hugging" and "bridging". "Hugging" means teaching so as to better meet the resemblance of conditions of "near transfer". For instance, teachers who will like students to use their knowledge of biology in thinking about current ecological problems might introduce that knowledge in the first place in the context of such problems. The aim is to activate a relational understanding between the study of biology and human survival on this globe. Teachers who want students to relate their study of literature to everyday life might emphasise literature where the connection is particularly plain for many students (Perkins and

Solomon, 1988, p. 28-29).

"Bridging" means teaching so as to meet better the conditions for "far transfer". Rather than expecting students to achieve transfer spontaneously, one "mediates" the needed processes of abstraction and connection-making. For example, teachers can point out explicitly the more general principles behind particular skills or knowledge or better provoke students to attempt such generalisation themselves. Here the objective of the teacher in the choice of method will be that at the end of the unit or lesson or the course, the students would have acquired the skill of "seeing through", of being able to identify basic underlying principles of a particular skill or knowledge. The identification of such "patterns" or "structure" or "principle" will induce relational application on the part of the student. This type of deep structural relation, if well connected during the teaching-learning process, will provoke students to have a relational understanding of this concept.

Thus "hugging" and "bridging" as a teaching technique is aimed at provoking students to generalise. Teachers already pose questions and organise activities of these sorts from time to time. There is ample reason to believe that bridging and hugging together could do much to foster in instructional settings. There have been few cases of positive results (Carver & Kalahari, 1987, Clement, 1985 a, b ; Clement & Gull, 1985).

Bridging Method of Teaching

a) Bridging from Information to Design: the hallmark of this type of instruction is that knowledge is considered not as mere "information" but as "design. To be able to teach knowledge in such a manner the teacher must look out for four important things. He/ she must watch out for the problem of disconnected knowledge in his presentation and teaching by answering the following important question. What is the purpose of this knowledge that I intend to impart? What is its basic structure? What are the model cases of this type of knowledge? What are the arguments that explain and evaluate it?

b) Bridging from Subject to Subject

Conventional schooling has not paid much attention to cross breeding of subject matter. This has led to many situations where students are not very likely to see relations between scholastic discipline and practical life, between school knowledge and practical problem-solving. Several subjects run their courses as separately. Yet building connections are not hard to find. Teachers are to teach in such a way as to make connections of their teaching with other subjects as well as with practical life.

Teaching to establish a mental set for Transfer: The techniques of Anticipatory and Retrieval tactics of teaching

All the above techniques of teaching that we have talked about in the preceding sections are in fact about teaching in such a way as to establish a mental set for transfer. To teach transfer implies looking at knowledge, not just as information but more especially as design that has to look for the purpose of knowledge, the structure of knowledge, the mental model cases of it and finally finding out the arguments that explain and evaluate knowledge. We have already suggested a few techniques whereby knowledge could be so utilised in the teaching-learning process to promote the application knowledge outside of contexts. All these have to do with transfer. In this section, we only want to sum

up briefly and give justification of what Perkins has referred to as “anticipatory” and “retrieval” aspects of teaching.

Anticipatory tactics

Instruction that is designed to foster a mental set for transfer can teach knowledge in the first place so as to promote transfer. Perkins (1988, p.227), presents the following outline:

a) LowRoad transfer by varied practice: .Let us suppose that a student confronts exercises that fairly transparently require the use of diagrams, exercises not just in plane geometry, but also in two or three other contexts, for example, diagramming sentences in English, diagramming atomic interactions in chemistry, and employing flow charts in learning to programme a computer. When given such extra contexts in low road transfer, then more likely, when the student faces logic problem, the student will think to use a diagram. To generalise, practice of a rule in varied contexts helps to cast that rule into a general form and make it accessible in new contexts.

b) High road transfer by abstraction of rules: Assuming that students learning geometry are asked to rely upon their own problem-solving processes and to generalise about elements of that process that seem to help. Some students may formulate the rule, “use a diagram”. As teacher, perhaps you can ask, “Is that a rule just for geometry or generally useful, and why?”. In other words, as a teacher you have to provoke and stimulate students to think about their thinking. So they reason about it and conclude that it is generally a useful rule. Thus deliberate abstraction can result in the recording of a rule at a more general level, more suitable for transfer to a wide range of contexts.

C) High road transfer by anticipating application: The above scenario can be extended. Suppose you ask the students not just to generalise rules, but to imagine where they might find use. The teacher can even suggests a range of contexts and ask whether a rule under discussion might prove applicable in those contexts. The teacher can possibly explore one or two applications.

Retrieval Tactics

The anticipatory tactics have as their aim how to prime learners learning for later transfer. However, high road transfer can be approached from another angle. While working in the application context, a person can make special retrieval effort that will recover knowledge bound to a prior learning context. The following are some suggested ways by Perkins (1988) by which instruction can foster such transfer.

a) High road transfer by generalising the problem. Suppose some students working on logic problem are encouraged to reflect on the difficulties they encounter. Perhaps one of them might have this to say: “It’s hard to keep track of all the information you are given”. May be with prompting from you, the teacher, the student extracts a general question: “What ways do I know to keep track of what a problem says?”. With this question as guide, the student may recall such tactics as making lists or diagrams.

b) High road transfer by focused retrieval: The teacher in order to stimulate a mental set for transfer in his teaching might for example, urge learners addressing logic problems to think of specific prior contexts to focus on. Perhaps one student might come up with: “Well, last year we studied geometry.

So maybe I can think of something from geometry". After a moment, the student comes up with, "Make a diagram". In general, reaching toward a particular potentiality relevant context of experience should foster transfer.

C) High road transfer by metaphor-making. Besides generalising their difficulties with logic problem, students can also recast the difficulties by asking metaphorical questions. "What have I encountered before that's *like* this in some way?" Perhaps a student posing such a question will think of plain geometry and make a diagram tactic. In general, the minds call for likenesses, even sometimes for rather loose and esoteric ones, may yield useful transfers of knowledge.

CONCLUSION

One of the core functions of schooling is the application of knowledge acquired to solve practical problems in life. This notwithstanding, knowledge application or transfer is not automatic. There is empirical evidence from some research work. Other research work also points to the fact that teaching (or training) could be manipulated to effect transfer taking into consideration those factors that are considered crucial in determining transfer.

For example, the fact that one has learnt some computer programming, does not necessarily imply that one can apply that knowledge to solving a problem in logic, even though they may share the same essential features, unless teaching is consciously designed to teach for transfer taking into consideration some of the above mentioned strategies. Teaching for transfer implies having some theoretical understanding of the psychological determining factors that promote or hinder transfer, and based on these factors, one can design effective instruction to foster generalisation and conceptual restructuring that are crucial to promoting transfer.

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