Transfer of Learning

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ABSTRACT

Transfer of learning occurs when learning in one context enhances (positive transfer) or undermines (negative transfer) a related performance in another context. Transfer includes **near transfer** (to closely related contexts and performances) and **far transfer** (to rather different contexts and performances). Transfer is crucial to education, which generally aspires to impact on contexts quite different from the context of learning. Research on transfer argues that very often transfer does not occur, especially ``far" transfer. However, sometimes far transfer does occur. Findings from various sources suggest that transfer happens by way of two rather different mechanisms. Reflexive or **low road transfer** involves the triggering of well-practiced routines by stimulus conditions similar to those in the learning context. Mindful or **high road transfer** involves deliberate effortful abstraction and a search for connections. Conventional educational practices often fail to establish the conditions either for reflexive or mindful transfer. However, education can be designed to honor these conditions and achieve transfer.

Key words:
Transfer
Learning

Teaching
Metacognition

Situated learning Local knowledge

Abstraction
Metacognition

Mindfulness
Representation

Transfer of Learning

Transfer of learning occurs when learning in one context or with one set of materials impacts on performance in another context or with other related materials. For example, learning to drive a car helps a person later to learn more quickly to drive a truck, learning mathematics prepares students to study physics, learning to get along with one's siblings may prepare one for getting along better with others, and experience playing chess might even make one a better strategic thinker in politics or business. Transfer is a key concept in education and learning theory because most formal education aspires to transfer. Usually the context of learning (classrooms, exercise books, tests, simple streamlined tasks) differs markedly from the ultimate contexts of application (in the home, on the job, within complex tasks). Consequently, the ends of education are not achieved unless transfer occurs. Transfer is all the more important in that it cannot be taken for granted. Abundant evidence shows that very often the hoped-for transfer from learning experiences does not occur. Thus, the prospects and conditions of transfer are crucial educational issues.

1. Transfer Defined

Transfer versus ordinary learning. In a sense, any learning requires a modicum of transfer. To say that learning has occurred means that the person can display that learning later. Even if the later situation is very similar, there will be some contrasts – perhaps time of day or the physical setting. So no absolute line can be drawn between ordinary learning and transfer.

However, transfer only becomes interesting as a psychological and educational phenomenon in situations where the transfer would not be thought of as ordinary learning. For example, a student may show certain grammar skills on the English test (ordinary learning) but not in everyday speech (the hoped-for transfer). The student may solve the problems at the end of the chapter (ordinary learning) but not similar problems when they occur mixed with others at the end of the course (the hoped-for transfer). In other words, talk of transfer is always at least implicitly contrastive: it assumes learning within a certain context and asks about impact beyond that context.

Positive versus negative transfer. Positive transfer occurs when learning in one context improves performance in some other context. For instance, speakers of one language find it easier to learn related than unrelated second languages. Negative transfer occurs when learning in one context impacts negatively on performance in another. For example, despite the generally positive transfer among related languages, contrasts of pronunciation, vocabulary, and syntax generate stumbling blocks. Learners commonly assimilate a new language's phonetics to crude approximations in their native tongue and use word orders carried over from their native tongue.

While negative transfer is a real and often problematic phenomenon of learning, it is of much less concern to education than positive transfer. Negative transfer typically causes trouble only in the early stages of learning a new domain. With experience, learners correct for the effects of negative transfer. From the standpoint of education in general, the primary concern is that desired positive transfers occur. Accordingly, the rest of this article focuses on positive transfer.

Near versus far transfer. Near transfer refers to transfer between very similar contexts, as for instance when students taking an exam face a mix of problems of the same kinds that they have practiced separately in their homework, or when a garage mechanic repairs an engine in a new model of car, but with a design much the same as in prior models. Far transfer refers to transfer between contexts that, on appearance, seem remote and alien to one another. For instance, a chess player might apply basic strategic principles such as ``take control of the center" to investment practices, politics, or military campaigns. It should be noted that ``near" and ``far" are intuitive notions that resist precise codification. They are useful in broadly characterizing some aspects of transfer but do not imply any strictly defined metric of ``closeness."

2. Prospects of Transfer

As noted earlier, transfer is especially important to learning theory and educational practice because very often the kinds of transfer hoped for do not occur. The classic investigation of this was conducted by the renowned educational psychologist E. L. Thorndike in the first decades of the 20th century. Thorndike examined the proposition that studies of Latin disciplined the mind, preparing people for better performance in other subject matters. Comparing the performance in other academic subjects of students who had taken Latin with those who had not, Thorndike (1923) found no advantage of Latin studies whatsoever. In other experiments, Thorndike and Woodworth (1901) sought, and generally failed to find, positive impact of one sort of learning on another. Thorndike concluded that transfer depended on ``identical elements" in two performances and that most performances were simply too different from one another for much transfer to be expected. In terms of the rough near-far distinction, near transfer is much more likely than far transfer.

Thorndike's early and troubling findings have reemerged again and again in other investigations. For instance, the advent of computer programming as a school subject matter stimulated the proposal that computer programming developed general problem solving skills, much as Latin was thought to cultivate mental discipline. Unfortunately, several experiments seeking a positive impact of learning to program on problem solving and other aspects of thinking yielded negative results (see Pea and Kurland 1984, Salomon and Perkins 1987).

Another learning experience that might impact broadly on cognition is literacy, the mastery of reading and writing. Wide-ranging transfer might be expected from experience with the cognitive demands of reading and writing and the cognitive structures that text carries. However, Scribner and Cole (1981) reported a study of an African tribe, the Vai, with an indigenous form of writing not accompanied by schooling. Using a variety of general cognitive instruments, they found no differences between Vai who had mastered this script and others who had not. They argued that the impact of literacy depends on immersion in diverse activities surrounding literacy, not on acquisition of reading and writing per se. The Vai only employed their script in a very specific way, in contrast with the many uses of literacy apparent in many cultures.

For still another example, researchers have looked for transfer effects between puzzles or games that are isomorphs of one another, sharing the same logical structure but presented or described in very different physical terms. For example, some research has focussed on the well-known Tower of Hanoi puzzle, that requires moving three (or more) rings of different sizes among three pegs according to certain rules. One isomorph involves a story about three extra-terrestrial monsters, each holding a

crystal globe of a different size. The rules for the monsters passing the globes to one another are logically equivalent to the rules for moving the disks from peg to peg.

It is not clear whether one should consider study of problem isomorphs near or far transfer, because isomorphs are near identical structurally but very different in external trappings. In any case, subjects usually do not recognize the connection between one isomorph and the other and hence do not carry over strategies they have acquired while working with one to the other. However, if the relationship is pointed out, then subjects can do so fruitfully (Simon and Hayes 1977).

While the preponderance of results concerning transfer appears to be negative, it is important to recognize that occasional positive findings have appeared. For instance, Clements and Gullo (1984) and Lehrer et al. (1988) achieved positive transfer from engagement in Logo computer programming to certain cognitive measures, including measures of divergent thinking. Ann Brown (1989) reported a series of studies showing positive transfer by preschool children of abstract concepts, for instance the idea of stacking objects to climb on to reach something, or the idea of mimicry as a defence mechanism in animals. Campione et al. (1991) report that when children are taught to self-monitor and self-direct themselves during reading in what has been called ``reciprocal teaching," this transfers also to learning in other text-mediated areas of learning such as social studies and mathematics. Salomon et al. (1989) showed that students can transfer from a computer program designed to make students more strategic readers to their performance a while later on writing, suggesting that what the students acquired was transferable tendencies to self-monitor and self-direct.

3. Transfer and Local Knowledge

As emphasized earlier, near transfer seems to have much better prospects than far transfer. Not only does this trend appear in the empirical findings, but it makes sense in terms of contemporary research on ``expertise." Since the 1970's, a number of investigators have built a case for the importance of ``local knowledge" (with knowledge taken in a broad sense to include skills, concepts, propositions, etc.). In areas as diverse as chess play, physics problem solving, and medical diagnosis, expert performance has been shown to depend on a large knowledge base of rather specialized knowledge (see Ericsson and Smith 1991). General cross-domain principles, it has been argued, play a rather weak role. In the same spirit, some investigators have urged that learning is highly situated, that is, finely adapted to its context (Brown et al. 1989, Lave 1988).

A strong local knowledge position would predict little far transfer under any conditions, because knowledge in one context would not be very relevant to others. However, the research on expertise does not really force such a position: The importance of local knowledge does not imply the unimportance of rather general knowledge that works together *with* local knowledge (Perkins and Salomon 1989). Moreover, the idea of situated learning does not necessarily imply that the prospects of transfer are limited. Greeno et al. (in press) offer a situated learning view of transfer in which transfer depends on similar opportunities for action across situations that may be very different superficially. In sum, a monolithic local knowledge position is difficult to sustain.

4. Conditions of Transfer

Positive findings of transfer, near and far, suggest that whether transfer occurs is too bald a question.

It can, but often does not. One needs to ask under what conditions transfer appears.

Thorough and diverse practice. Consider again the question of literacy. In a classic study of the impact of literacy and education in Russia, Luria (1976) found major influence on a number of cognitive measures. His results concerned a population where reading and writing played multiple roles. The contrast between Luria's and Scribner and Cole's findings suggests that transfer may depend on extensive practice of the performance in question in a variety of context. This yields a flexible relatively automatized bundle of skills easily evoked in new situations.

Explicit abstraction. Transfer sometimes depends on whether learners have abstracted critical attributes of a situation. In one demonstration, Gick and Holyoak (1980, 1983) presented subjects with a problem story that allowed a particular solution. From subjects that solved the problem, they elicited what the subjects took to be the underlying principle. Then they presented the subjects with another analogous problem that invited a similar approach. Those subjects with the fullest and soundest summary of the principle for the first puzzle were most successful with the second. These and other results suggest that explicit abstractions of principles from a situation foster transfer.

Active self-monitoring. Relatedly, metacognitive reflection on one's thinking processes appears to promote transfer of skills. This contrasts with the explicit abstraction category above in that abstraction focuses on the structure of the situation whereas self-monitoring focuses on one's own thinking processes. Belmont et al. (1982) undertook a synthesis of a number of efforts to teach retarded children simple memory strategies and to test whether the children would apply these in slightly different contexts. Many of these studies showed no transfer, while a few revealed some. The researchers isolated the factor that appeared to account for success: teaching the children not just to apply the strategy but to monitor their own thinking processes in simple ways. Presumably, this activation of self-monitoring helped the children later to recognize when they might apply the strategy they had learned.

Arousing mindfulness. Mindfulness refers to a generalized state of alertness to the activities one is engaged in and to one's surroundings, in contrast with a passive reactive mode in which cognitions, behaviors, and other responses unfold automatically and mindlessly (Langer 1989). More encompassing than explicit abstraction and active self-monitoring, mindfulness would foster both of those.

Using a metaphor or analogy. Transfer is facilitated when new material is studied in light of previously learned material that serves as an analogy or metaphor. Things known about the ``old" domain of knowledge can now be transferred to a ``new" domain thereby making it better understood and learned. For example, students may initially understand the idea of an atom better by thinking of it as a small solar system, or how the heart works by thinking of it as a pump. Of course, most such analogies are limited and need elaboration and qualification.

5. Mechanisms of Transfer

Why do factors of the kind identified above encourage transfer? Answers to that question can best come from an examination of the mechanisms of transfer, the psychological paths by which transfer occurs.

Abstraction. It is still possible today to grant Thorndike's point that identical elements underlie the phenomenon of transfer. However, research suggests that a more complex picture of how identical elements figure in the process of transfer. An identity that mediates transfer can sit at a very high level of abstraction. Phenomena such as the branching of arteries and that of electrical power networks can evince the same deep principle (the need to deliver something to a region point by point) with great differences in what constitutes a conduit (arteries versus wires) and the something being carried (blood versus electricity). Such a degree of abstraction helps to account for far transfer, because highly abstract identical elements can appear in very different contexts.

Transfer by affordances. Writing from the perspective of situated cognition, Greeno et al. (in press) argue that transfer need not depend on mental representations that apply to the learning and target situations. Rather, during initial learning, the learner may acquire an action schema responsive to the affordances — the action opportunities — of the learning situation. If the potential transfer situation presents similar affordances and the person recognizes them, the person may apply the same or a somewhat adapted action schema there. External or internal representations may or may not figure in the initial learning or the resulting action schema.

High road and low road transfer. Salomon and Perkins (1989, Perkins and Salomon 1987) synthesized findings concerned with transfer by recognizing two distinct but related mechanisms, the ``low road" and the ``high road." Low road transfer happens when stimulus conditions in the transfer context are sufficiently similar to those in a prior context of learning to trigger well-developed semi-automatic responses. In keeping with the view of Greeno et al. (in press), these responses need not be mediated by external or mental representations. A relatively reflexive process, low road transfer figures most often in near transfer. For example, when a person moving a household rents a small truck for the first time, the person finds that the familiar steering wheel, shift, and other features evoke useful car-driving responses. Driving the truck is almost automatic, although in small ways a different task.

High road transfer, in contrast, depends on mindful abstraction from the context of learning or application and a deliberate search for connections: What is the general pattern? What is needed? What principles might apply? What is known that might help? Such transfer is not in general reflexive. It demands time for exploration and the investment of mental effort. It can easily accomplish far transfer, bridging between contexts as remote as arteries and electrical networks or strategies of chess play and politics. For instance, a person new to politics but familiar with chess might carry over the chess principle of control of the center, pondering what it would mean to control the *political* center.

In a particular episode of transfer, the two roads can work together — some connections can occur reflexively while others are sought out. But in principle the two mechanisms are distinct.

This framework matches well a number of the points made earlier. It acknowledges that sometimes transfer is stimulus driven, occurring more or less automatically as a function of much and diverse practice (the low road). On the other hand, sometimes transfer involves high levels of abstraction and challenges of initial detection of possible connections (the high road). The framework makes room for identical elements in Thorndike's original sense — identities that the organism simply responds to (the low road) — but insists on the importance of identities discovered and exploited by mindful

exploration (the high road).

This analysis along with the views and findings of Luria, Scribner and Cole, Greeno, and others emphasizes that the conditions for transfer are stringent. Reflexive (low road) transfer requires well-automatized patterns of response that are thus easily triggered by similar stimulus conditions — and it requires stimulus conditions enough like prior contexts of learning to act as triggers. Many learning situations offer practice only for a narrow range of examples and not enough practice to achieve significant automaticity, providing a poor basis for reflexive transfer. Mindful (high road) transfer requires active abstraction and exploration of possible connections. Many learning situations do not encourage such mental investments, although people more inclined to mindfulness or metacognition are by definition more likely to make them.

6. Teaching for Transfer

These points about mechanism clarify why transfer does not occur as often as would be wished. They also provide guidelines for establishing conditions of learning that encourage transfer.

In many situations, transfer will indeed take care of itself — situations where the conditions of reflexive transfer are met more or less automatically. For example, instruction in reading normally involves extensive practice with diverse materials to the point of considerable automaticity. Moreover, when students face occasions of reading outside of school — newspapers, books, assembly directions, and so on — the printed page provides a blatant stimulus to evoke reading skills.

In contrast, in many other contexts of learning, the conditions for transfer are less propitious. For example, social studies are normally taught with the expectation that history will provide a lens through which to see contemporary events. Yet the instruction all too commonly does not include any actual practice in looking at current events with a historical perspective. Nor are learners encouraged to reflect upon the eras they are studying and extract general widely applicable conclusions or even questions. In other words, the conventions of instruction work against both automatic (low road) and mindful (high road) transfer.

In response to such dilemmas, one can define two broad instructional strategies to foster transfer: hugging and bridging (Perkins and Salomon 1988). Hugging exploits reflexive transfer. It recommends that instruction directly engage the learners in approximations to the performances desired. For example, a teacher might give students trial exams rather than just talking about exam technique, or a job counselor might engage students in simulated interviews rather than just talking about good interview conduct. The learning experience thus ``hugs'' the target performance, maximizing likelihood later of automatic low road transfer.

Bridging exploits the high road to transfer. In bridging, the instruction encourages the making of abstractions, searches for possible connections, mindfulness, and metacognition. For example, a teacher might ask students to devise an exam strategy based on their past experience, a job counselor might ask students to reflect on their strong points and weak points and make a plan to highlight the former and downplay the latter in an interview. The instruction thus would emphasize deliberate abstract analysis and planning. Of course, in the cases of exam technique and job interview, the teachers might do both. Instruction that incorporates the realistic experiential character of hugging

and the thoughtful analytic character of bridging seems most likely to yield rich transfer.

In summary, a superficial look at how research on transfer casts its vote is discouraging. The preponderance of studies suggest that transfer comes hard. However, a closer examination of the conditions under which transfer does and does not occur and the mechanisms at work presents a more positive picture. Education can achieve abundant transfer if it is designed to do so.

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