Introduction to "New Conceptualizations of Transfer of Learning"

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Introduction to "New Conceptualizations of Transfer of Learning"

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Understanding how to get learners to transfer their knowledge to new situations is a topic of both theoretical and practical importance. Theoretically, it touches on core issues in knowledge representation, analogical reasoning, generalization, embodied cognition, and concept formation. Practically, learning without transfer of what has been learned is almost always unproductive and inefficient. Although schools often measure the efficiency of learning in terms of speed and retention of knowledge, a relatively neglected and subtler component of efficiency is the generality and applicability of the acquired knowledge. This special issue of *Educational Psychologist* collects together new approaches toward understanding and fostering appropriate transfer in learners. Three themes that emerge from the collected articles are (a) the importance of the perspective/stance of the learner for achieving robust transfer, (b) the neglected role of motivation in determining transfer, and (c) the existence of specific, validated techniques for teaching with an eye toward facilitating students' transfer of their learning.

Most educators want their students to apply what they have learned beyond its original classroom context. Biology teachers want their students to understand the genetic mechanisms underlying heredity, not simply how pea plants look. Physics teachers want their students to understand fundamental laws of physics such as conservation of energy, not simply how a particular spring uncoils when weighted down. Unfortunately, having students transfer what they have learned to new scenarios that draw on the same principles has proven surprisingly difficult to achieve (Detterman, 1993; Gick & Holyoak, 1980, 1983). Considerable research indicates that students often do not spontaneously transfer what they have learned, at least not across superficially dissimilar scenarios. In one striking example, Perkins (2009) cited the amusing, but also horrifying, case of physics students who learned in class how to determine how long it would take a ball to fall to the bottom of a certain height tower (see Figure 1A) and then were given on an exam the problem of determining how long it would take a ball to fall to the bottom of a well (the scenario on the right). Students complained that they were not given any well problems in class.

However, there are recent suggestions that students can, under some circumstances, transfer their knowledge across superficially dissimilar domains (Pedone, Hummel, & Holyoak, 2001; Schwartz, Bransford, & Sears, 2005; Schwartz, Sears, & Chang, 2007). In fact, in some cases, transfer seems to be spontaneous and automatic. When people are first shown the ambiguous object B in Figure 2 next to A, they tend to interpret it as having three prongs. However, when B is paired with C, it is interpreted as having four prongs—three normal prongs and one stunted (Medin, Goldstone, & Gentner, 1993). This kind of perceptual priming is not typically construed as transfer, but it does represent a clear case in which people spontaneously carry along acquired interpretational strategies without explicitly trying to apply their learning to new situations.

The goal of this special issue of *Educational Psychologist* is to synthesize new theoretical positions, informed by empirical data, about whether and how transfer of knowledge is achievable. This is a timely topic for *Educational Psychologist* because of the recent resurgence of interest in transfer. Part of the reason for this resurgence is the renewed

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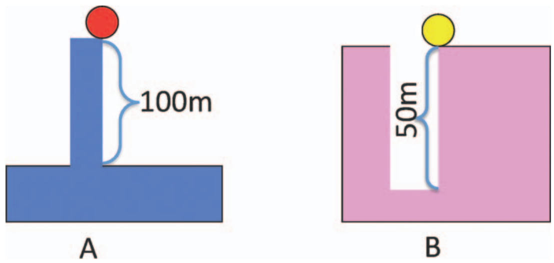

FIGURE 1 A graphic illustration of the challenge of transferring acquired knowledge. *Note.* David Perkins (2009) reported a physics classroom in which students were first given falling ball problems of the kind illustrated in A. Students were shown how to determine how long it would take the ball at the top of the 100-m tower to reach the ground. They were later tested on problems such as B in which a ball started at the top of a 50-m well and fell down to the bottom. Several students complained that they had never been given "well" problems before, only "tower" problems (color figure available online).

understanding that important principles frequently arise in different domains. For example, complex systems principles such as positive and negative feedback loops arise in economics, geology, physics, chemistry, biology, and the social sciences (Chi & VanLehn, 2012/this issue; Goldstone & Wilensky, 2008). Students who learn about a positive feedback systems from an example of a microphone feeding into, and placed near, a loudspeaker are missing out on an opportunity for applying their knowledge to an economics situation of people purchasing products that other people had already purchased if they do not engage in cross-domain transfer. It is true that there is a major trend in science toward increasingly specialized research topics. However, there is also a scientific movement to reverse this trend, pursuing the possibility that the same principles can describe seemingly very different phenomena. One attractive aspect of this movement from an educational perspective is that it promotes a view of science that is enfranchising rather than alienating. Students who can apply the Diffusion-limited Aggregation principle that they learned while exploring copper sulfate formations to the growth and structure of cities, lungs, and snowflakes (Ball, 2011) will likely develop an appreciation of science in which any field can potentially bear on another field (Chi, 2005; Chi, Slotta, & deLeeuw, 1994).

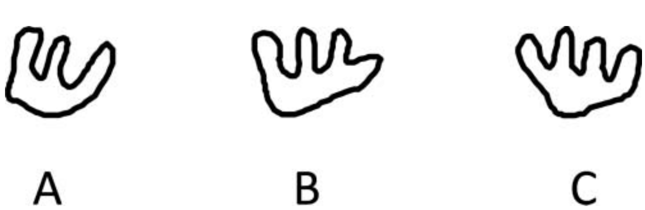

FIGURE 2 An example based on stimuli from Medin, Goldstone, and Gentner (1993). Mutually exclusive interpretations are given for the ambiguous object B, depending on whether it is paired with A or C. B is spontaneously interpreted as possessing three prongs when presented with A and four prongs when presented with C.

Another reason for a renewed interest in transfer in cognitive science and education is that there has been a methodological shift from measuring transfer by learners' explicit statements of correspondence between domains to implicit, indirect measures that students may be sensitive to the connection between situations without being able to explicitly verbalize the basis for the connection. This expanded view of what counts as evidence for transfer has taken several forms. Some researchers have focused on how students learn how to see events as manifesting principles, and how this learning prepares them for seeing future events in terms of the same principles (Bransford & Schwartz, 1999). Other researchers have looked for indications that students have been influenced by previous activities by examining how they construe situations as similar to the earlier activity (Lobato, 2003, 2012/this issue; Lobato & Seibert, 2002). Similarly, researchers have argued for transfer occurring by students developing perceptual interpretations of an initial situation and simply continuing to use the same interpretational bias when interacting with a second situation (Day & Goldstone, 2011, 2012/this issue; Goldstone, Landy, & Son, 2010).

The specific goals of this special issue are to discuss what we know about transfer of learning and how best to foster it. The contributed articles tackle core questions such as

- How is transfer best conceptualized?
- Is transfer of learning to (apparently) dissimilar situations a viable, and valuable, goal?
- How is transfer affected by the ways in which materials are presented by instructors and approached by students?
- What are the best methods of pedagogical practice for fostering transfer?
- What are the cognitive, distributed, and social processes that underlie transfer?
- What are the roles of context, perception, grounding, rules, and formalisms for achieving transfer?

INTEGRATIVE THEMES

As a way of orienting the reader to the articles to follow, we briefly mention three themes that unify the contributions and are likely prospects for fertile future research. A first theme is that the perspective and active learning stance of the learner makes a critical difference for transfer. Whether transfer occurs is not simply a function of the similarity between the original and new situations. It is fundamentally a function of the proclivity of the learner to make a connection between the situations. This theme prominently appears in Lobato's (2012/this issue) "actor-inspired" approach that focuses on what a learner stands to benefit from transferring their previous learning, and Engle, Lam, Meyer, and Nix's (2012/this issue) prescriptions for encouraging students to frame what they are learning in an expansive fashion to foster transfer. Schwartz, Chase, and Bransford (2012/this issue) focused on the need for students to adopt a mind-set in which they are oriented toward adapting, not just applying, their knowledge. For Chi and VanLehn (2012/this issue) and Lobato (2012/this issue), transfer literally involves adopting new perspectives—developing new ways of seeing familiar situations. At a broader level, Richland, Stigler, and Holyoak (2012/this issue) reported evidence indicating that entire cultures differ in the emphases that they place on connecting situations. Sensitivity to individual and cultural differences in the quantity and quality of cross-situational connections will be important for tailoring teaching for transfer and for finding ways to inspire students to be "intellectual entrepreneurs" who proactively create their own opportunities for leveraging their prior knowledge. The approaches described in the following articles collectively indicate that transfer can occur in a diversity of ways when learners are actively involved in interpreting new situations. A greater appreciation of the diversity of transfer may help us to see troubling aspects of positive transfer (Schwartz et al., 2012/this issue) as well as positive aspects of so-called negative transfer (Lobato, 2012/this issue). All too often, negative transfer is shorthand for "transfer in a way that conflicts with what the teacher/experimenter intended." Learners have their own agendas, and understanding these agendas will help us help students apply their previous experiences in a useful and generative manner.

A second theme particularly emphasized in Perkins and Salomon's (2012/this issue) discussion is the need to reconcile the cognitive bases for transfer with motivational considerations. Even if a student possesses ideal cognitive abilities for drawing apt connections among experiences, opportunities for transfer will still be forfeited if the student is not motivated to draw out these connections. Cognitive work is necessary for properly taking in experiences, for transforming these experiences into transportable encodings, and for figuring out how these encodings are applicable to new situations. The issue here is not only how to inspire students to do this cognitive work but how to inspire them to inspire themselves to interpret their world in useful ways. Standard approaches to transfer from cognitive science have underemphasized the importance of motivation for achieving transfer, and incorporating motivation into cognitive accounts will allow these accounts to better explain successful and unsuccessful cases of transfer (Belenky & Nokes-Malach, 2012).

A third theme is that efforts to teach students with an eye toward transfer will incorporate a diverse set of methods aimed at training flexible thinking. Whereas many training programs emphasize "accelerated learning," speed should not be viewed as the only measure of efficiency. The generalization potential for learning is just as important a facet of efficiency, even though far more research on assessment is needed to develop adequate measures of generalization potential. Several specific proposals for training flexibility in thought are presented in the articles that follow: focusing on interactions between surface features (Chi & VanLehn, 2012/this issue), invention-based training (Schwartz et al., 2012/this issue), comparison-based training (Richland et al., 2012/this issue), actor-oriented approaches (Lobato, 2012/this issue), taking advantage of well-grounded perception and action processes (Day & Goldstone, 2012/this issue), and explicit framings to encourage developing transportable representations (Engle et al, 2012/this issue). Rote training procedures may achieve efficient learning of specific behaviors, but this is only a short-term goal. The "real" goal is for learners to behave in a thoughtful and adaptive manner. Learning scientists risk falling into exactly the same "failure to generalize" trap that they have documented so well in their experimental subjects if they insist on measuring only the most easily quantified variables of response time and percent correct on problems sampled from the same set as the training problems (D. Schwartz, personal communication, August 5, 2011). Fortunately, the current contributions attest to our collective ability to avoid limited learning from our previous studies and theories by simply switching from one rote procedural training system to another. At our best, we are "learning scientists" in both senses of the phrase—scientists that study learning and scientists that are learning from our predecessors', and our own, mistakes.

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