Situated Learning and Education[1]

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This paper provides a review of the claims of situated learning that are having an increasing influence on education generally and mathematics education particularly. We review the four central claims of situated learning with respect to education: (1) action is grounded in the concrete situation in which it occurs; (2) knowledge does not transfer between tasks; (3) training by abstraction is of little use; and (4) instruction must be done in complex, social environments. In each case, we cite empirical literature to show that the claims are overstated and that some of the educational implications that have been taken from these claims are misguided.

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Following on the so-called "cognitive revolution" in psychology that began in the 1960s, education, and particularly mathematics and science education, has been acquiring new insights from psychology and new approaches and instructional techniques based on these insights. At the same time, cognitive psychologists have being paying increasing attention to education as an area of application of psychological knowledge and as a source of important research problems. As research in cognitive psychology progresses and increasingly addresses itself to educational issues, even closer and more productive links can be formed between psychology and mathematics education.

However, some educational opinion, including opinion that is quite contrary to the body of empirical evidence available on these matters, is presented as deriving from cognitive psychology. For instance, Lesh and Lamon (1992) write in the introduction to a recent book they edited:

> Behavioral psychology (based on factual and procedural rules) has given way to cognitive psychology (based on models for making sense of real-life experiences), and technology-based tools have radically expanded the kinds of situations in which mathematics is useful, while simultaneously increasing the kinds of mathematics that are useful and the kinds of people who use mathematics on a daily basis. In response to these trends, professional and governmental organizations have reached an unprecedented, theoretically sound, and future-oriented new consensus about the foundations of mathematics in an age of information. (p. 18–19)

As in many recent publications in mathematics education, much of what is described in the Lamon and Lesh book reflects educational implications that have been drawn from two movements—"situated learning" and "constructivism"—which have been gaining influence on thinking about education and educational research. Much of what is claimed by these movements is not "theoretically sound." This paper will focus on situated learning. Elsewhere (Anderson, Reder, & Simon, 1995) we have written on the excesses of constructivism. However, constructivism is primarily a philosophical position, whereas situated learning has strong empirical consequences that are not always borne out. In this paper, we want to concentrate on empirical evidence and its implications for mathematics education.

Situated learning (e.g., Lave, 1988; Lave & Wenger, 1991; Greeno, Smith, & Moore, 1992) emphasizes the idea that much of what is learned is specific to the situation in which it is learned. While implications have been drawn from situated learning for all aspects of education, this paper will focus primarily on mathematics education. This is because many of the examples from the situated learning literature involve mathematics, and it has particularly influenced researchers in mathematics education (e.g., Cobb, Yackel, & Wood, 1992; Lesh & Zawojeski, 1992; Resnick, 1994). Particularly important has been situated learning's emphasis on the mismatch between typical school situations and "real world" situations such as the workplace, where one needs to deploy mathematical knowledge. Greater emphasis should be given to the relationship between what is learned in the classroom and what is needed outside of the classroom, and this has been a valuable contribution of the situated learning movement. However, while it is important to have our consciousness raised about this issue, the claims from the situated learning camp are often inaccurate. Moreover, the educational implications taken from these claims (not always endorsed by the original situated authors) are often mistaken.

Two of us have been involved in past reviews relevant to situated learning—Simon in support of the mutual compatibility of modern information processing theory and situated cognition (Vera & Simon, 1993) and Reder in an assessment of the effectiveness for training of techniques located at various points along the scale of "situatedness" (Reder & Klatzky in a report of the National Research

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Council, 1994). We will focus on the four claims of situated learning identified in the NRC report.

Claim 1: Action Is Grounded in the Concrete Situation in Which It Occurs

That action is situationally grounded is surely the central claim of situated cognition. It means that the potentialities for action cannot be fully described independently of the specific situation, a statement with which we fully concur. However, the claim is sometimes exaggerated to assert that all knowledge is specific to the situation in which the task is performed and that more general knowledge cannot and will not transfer to real-world situations. One supposed example is Lave's (1988) description of Orange County homemakers who did very well at making supermarket best-buy calculations but who did much worse on arithmetically equivalent school-like paper-and-pencil mathematics problems. Another frequently cited example is Carraher, Carraher, and Schliemann's (1985) account of Brazilian street children who could perform mathematics when making sales in the street but were unable to answer similar problems presented in a school context. As Lave (1988) asserts in summarizing this research:

> In sum, arithmetic practices are made to fit the activity at hand, and there are discontinuities between the techniques used to solve arithmetic problems in school-like situations and in the situations of shopping, selling produce, cooking, making and selling clothes, and assembling truckloads of dairy products. Place-holding algorithms do not transfer from school to everyday situations, on the whole. On the other hand, extraordinarily successful arithmetic activity takes place in these chore and job settings. (p. 149)

Even if these claims are valid and generalizable beyond these specific cases, they demonstrate at most that particular skills practiced in real-life situations do not generalize to school situations. They assuredly do not demonstrate the converse. That is, it does not follow from these examples that arithmetic procedures taught in the classroom cannot be used by a shopper to make price comparisons or a street vendor to make change. Such observations call for closer analyses of the task demands and the use of the analyses to devise teachable procedures that will achieve a balance between the advantages of generality and the advantages of incorporating enough situational context to make transfer likely. They also call for research on the feasibility of increasing the application and transfer of knowledge by including ability to transfer as a specific goal in instruction, a skill that is given little attention in most current instruction.

At one level, there is nothing new in this claim about the contextualization of learning. There have been numerous demonstrations in experimental psychology that learning can be contextualized (e.g., Godden & Baddeley, 1975; Smith, Glenberg, & Bjork, 1978). For instance, Godden and Baddeley found that divers had difficulty remembering under water what they learned on land or vice versa. However, it is not the case that learning is wholly tied to a specific context. For instance, Godden and Baddeley's divers could remember some of what they learned in the other context. In fact, there are many demonstrations of learning that transfer across contexts and of failures to find any context specificity in the learning (e.g., Fernandez & Glenberg, 1985; Saufley, Otaka, & Bavaresco, 1985)—a fact that has often frustrated researchers who were looking for context sensitivity.

How tightly learning will be bound to context depends on the kind of knowledge being acquired. Sometimes knowledge is necessarily bound to a specific context by the nature of instruction. Thus, to give a mathematics example, one would not be surprised to learn that, given typical instruction, carrying is bound to the context of doing base-10 addition and would not generalize to another base system. In other cases, how contextualized the learning is depends on the way the material is studied. If the learner elaborates the knowledge with material from a specific context, it becomes easier to retrieve the knowledge in that same context (Eich, 1985), but perhaps harder in other contexts. One general result is that knowledge is more context-bound when it is just taught in a single context (Bjork & Richardson-Klavehn, 1989).

Clearly, some skills such as reading transfer from one context to another. The very fact that we can engage in a discussion of the context-dependence of knowledge is itself evidence for the context-independence of reading and writing competence. Many of the demonstrations of contextual-binding from the situated camp involve mathematics, but clearly mathematical competence is not always contextually bound either. Although the issue has seldom been addressed directly, the psychological research literature is full of cases where mathematical competence has transferred from the classroom to all sorts of laboratory situations (sometimes bizarre—the intention was never to show transfer of mathematical skills—e.g., Bassok & Holyoak, 1989; Elio, 1986; Reder & Ritter, 1992). It is not easy to locate the many published demonstrations of mathematical competence generalizing to novel contexts; these results are not indexed under "context-independence of mathematical knowledge" because until recently this did not seem to be an issue.

The literature on situation-specificity of learning often comes with a value judgment about the merits of knowledge tied to a nonschool context relative to school-taught knowledge and an implied or expressed claim that school knowledge is not legitimate. Lave (1986, 1988, p. 195) goes so far as to suggest that school-taught mathematics serves only to justify an arbitrary and unfair class structure. The implication is that school-taught competences do not contribute to on-the-job performance. However, numerous studies show modest to large correlations between school achievement and work performance (e.g., Hunter & Hunter, 1984; Bossiere, Knight, & Sabot, 1985) even after partialing out the effects of general ability measures (which are sometimes larger).

Claim 2: Knowledge Does Not Transfer Between Tasks

This second claim of situated cognition—of the failure of knowledge to transfer—can be seen as a corollary of the first. If knowledge is wholly tied to the context of its acquisition, it will not transfer to other contexts. However, even without assuming extreme contextual dependence, one could still claim that there is relatively little transfer beyond nearly identical tasks to different physical contexts. Indeed, Lave (1988) argues that there is no empirical evidence for such general transfer and asserts:

It is puzzling that learning transfer has lasted for so long as a key conceptual bridge without critical challenge. The lack of stable, robust results in learning transfer experiments as well as accumulating evidence from cross-situational research on everyday practice, raises a number of questions about the assumptions on which transfer theory is based—the nature of cognitive "skills," the "contexts" of problem-solving and "out of context" learning, the normative sources of models of good thinking and less than perfect "performances." (p. 19)

Contrary to Lave's opinion, a large body of empirical research on transfer in psychology, going back at least to Weber in 1844 and Fechner in 1858 (Woodworth, 1938, chap. 8), demonstrates that there can be either large amounts of transfer, a modest amount of transfer, no transfer at all, or even negative transfer. How much there is and whether transfer is positive depends in reliable ways on the experimental situation and the relation of the material originally learned to the transfer material.

The more recent psychological literature (for two relatively recent reviews, see Perkins & Salomon, 1989; Singley & Anderson, 1989) contains many failures to achieve transfer (e.g., Gick & Holyoak, 1980; Hayes & Simon, 1977; Reed, Ernst, & Banerji, 1974; Weisberg, DiCamillo, & Phillips, 1985), but also contains many successful demonstrations of transfer (e.g., Brown, 1994; Brown & Campione, 1994; Kotovsky & Fallside, 1989; Lehman, Lempert, & Nisbett, 1988; Pennington, Nicolich, & Rahm, 1995; Schoenfeld, 1985; Singley & Anderson, 1989; Smith, 1986). Indeed, in the same domain (Tower of Hanoi isomorphs), quite different amounts of transfer occur depending on the amount of practice with the target task and on the representation of the transfer task (Kotovsky & Fallside, 1989). Representation and degree of practice are critical for determining the transfer from one task to another.

Singley and Anderson (1989) showed that transfer between tasks is a function of the degree to which the tasks share cognitive elements. This hypothesis had also been put forth very early in the development of research on transfer (Thorndike & Woodworth, 1901; Woodworth, 1938), but was hard to test experimentally until we acquired our modern capability for identifying task components. Singley and Anderson taught subjects several text editors one after another and sought to predict transfer (savings in learning a new editor when it was not taught first). They found that subjects learned subsequent text editors more rapidly and that the number of procedural elements shared by two text editors predicted the amount of this transfer. In fact, they obtained large transfer across editors that were very different in surface structure but that had common abstract structures. Singley and Anderson also found that similar principles govern transfer of mathematical competence across multiple domains, although here they had to consider transfer of declarative as well as procedural knowledge. As a general statement of this research, transfer varied from one domain to another as a function of the number of symbolic components that were shared. If anything, Singley and Anderson's results showed slightly more transfer than was predicted by their theory.

Klahr and Carver (1988) showed that a detailed information-processing analysis can be critical to designing instruction that will achieve transfer of knowledge. They examined the issue of transfer of LOGO debugging skills to other domains. As they note, there have been wildly optimistic claims about such transfer and disappointing results. Klahr and Carver show that one can get transfer if one performs a componential analysis of the structure of LOGO debugging and the structure of the transfer task and provides instruction in LOGO designed to teach the common components.

What about the situations in which subjects have shown relatively little transfer? In one famous series of studies (Gick & Holyoak, 1980, 1983), subjects were presented with Duncker's (1945) classic radiation problem: "Suppose you are a doctor faced with a patient who has an inoperable stomach tumor. You have at your disposal rays that can destroy human tissue when directed with sufficient intensity. How can you use these rays to destroy the tumor without destroying the surrounding healthy tissue?" (adapted from Gick & Holyoak, 1983). Prior to their exposure to the target problem, subjects read a story about an analogous military problem and its solution. In the story, a general wishes to capture an enemy fortress. Radiating outward from the fortress are many roads, each mined in such a way that the passing of any large force will cause an explosion. This precludes a full-scale direct attack. The general's plan is to divide his army, send a small group down each road, and converge on the fortress. The common strategy in both problems is to divide the force, attack from different sides, and converge on the target. After reading this story, however, only about 30% of the subjects could solve the radiation problem, which is only a "limited" improvement (although an improvement by a factor of three) over the 10% baseline solution rate (Gick & Holyoak, 1980).

A striking characteristic of such partial failures of transfer is how relatively transient they are. Gick and Holyoak increased transfer greatly just by suggesting to subjects that they try to make use of the problem about the general. Exposing subjects to two such analogs also greatly increased transfer. The amount of transfer appeared to depend in large part on where the attention of subjects was directed during the experiment, which suggests the desirability of instruction and training on the cues that signal the relevance of an available skill. A number of studies converge on the conclusion that transfer is enhanced when training involves multiple examples and encourages learners to reflect on the potential for transfer (e.g., Bransford, Franks, Vye, & Sherwood, 1989; Brown & Kane, 1988; Ghatala, Levin, Pressley, & Lodico, 1985; Pressley, Borkowski, & Schneider, 1987).

In research on transfer, there has been a tendency to look for it where one is least likely to find it. That is, research tends to look for transfer from little practice in one domain to initial performance in another domain. Superficial differences between the two domains will have their largest negative effect when the domains are unfamiliar. We do not require that students show the benefit of one day of calculus on the first day of physics. Rather, we expect that they will be better physics students at year's end for having had a year's study of calculus.

Contrary to the claim that knowledge does not transfer between tasks, the evidence we have reviewed supports the following conclusions:

(1) Depending upon the experimental situation and the relation of the material originally learned to the transfer

material, there can be either large amounts of transfer, a modest amount, no transfer at all, or even negative transfer.

(2) Representation and degree of practice are major determinants of the transfer from one task to another, and transfer varies from one domain to another directly with the number of symbolic components that are shared.

(3) The amount of transfer depends on where attention is directed during learning or at transfer. Training on the cues that signal the relevance of an available skill should probably receive more emphasis in instruction than it now typically receives.

Claim 3: Training By Abstraction Is of Little Use

The claim that training by abstraction is of little use is also a corollary of the claims just discussed. Nonetheless, one might argue for it even if one dismisses the others. Claim 3 has been extended into an advocacy for apprenticeship training (Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989). As Collins, Brown, and Newman assert:

> The differences between formal schooling and apprenticeship methods are many, but for our purposes, one is most important. Perhaps as a by-product of the relegation of learning to schools, skills and knowledge taught in schools have become abstracted from their uses in the world. In apprenticeship learning, on the other hand, target skills are not only continually in use by skilled practitioners, but are instrumental to the accomplishment of meaningful tasks. (p. 453–454)

What is meant by advocacy of apprenticeship training can vary from advocacy of certain rather traditional pedagogical strategies such as modeling in traditional classrooms to the claim that the most effective training is real apprenticeship to workers in their real-world environments. The stronger versions of this claim clearly challenge the legitimacy of school-based instruction.

Abstract instruction can be ineffective if what is taught in the classroom is not what is required on the job. Often this is an indictment of the design of the classroom instruction rather than of the idea of abstract instruction in itself. However, sometimes it is an indictment of the job situation. For instance, Los Angeles police after leaving the police academy are frequently told by more experienced officers "now forget everything you learned" (Independent Commission on the Los Angeles Police Department, 1991, p. 125). The consequence is that police officers are produced who, ignoring their classroom training in the face of contrary influences during apprenticeship, may violate civil rights and make searches without warrants. Clearly, one needs to create a better correspondence between job performance and abstract classroom instruction, and sometimes this means changing the nature of the job (including the structure of motivations and rewards) and fighting unwanted and deleterious effects of apprenticeship learning.

Abstract instruction can be very effective. In unpublished research, Singley found that abstract instruction leads to successful transfer, while concrete instruction can lead to failure of transfer. He taught subjects to solve algebra word problems involving mixtures. Some subjects were trained with pictures of the mixtures while other subjects were trained with abstract tabular representations that highlighted the underlying mathematical relationships. The abstract training group was able to transfer better to other kinds of problems that involved analogous mathematical relations. Perhaps the most striking demonstration of the benefit of abstract instruction comes from Biederman and Shiffrar (1987). They looked at the very difficult task of sexing day-old chicks—something that people spend years learning in an apprentice-like role. They found that 20 minutes of abstract instruction brought novices up to the levels of experts who had years of practice.

The issue of choosing between abstract and very specific instruction can be viewed in the following way. If abstract training is given, learners must also absorb the money and time costs of obtaining supplemental training for each distinct application. But if very specific training is given, they must completely retrain for each application. Which is to be preferred, and to what extent, depends on the balance among (a) the cost of the more general abstract training, (b) the cost of the specific training, (c) the cost of the supplemental training for application of abstract training, and (d) the range of jobs over which the learner is likely to have occasion to apply what was learned. Someone who will spend years performing a single set of very specific tasks might be well advised to focus on specific training. But if the cost of supplemental training is not large (i.e., if there is substantial transfer over the range of tasks), if technological or other changes are likely to alter tasks substantially over the years, or if the range of tasks the learner is likely to address over time is substantial, then abstract training with supplemental applications training is clearly preferable. It is easy to work out an exercise of this kind by assigning numbers to the various costs and to the variability of the tasks encountered and thereby to show that there is no solution that is optimal for all cases.

Most modern information-processing theories in cognitive psychology are "learning-by-doing," theories which imply that learning would occur best with a combination of abstract instruction and concrete illustrations of the lessons of this instruction. Numerous experiments show combining abstract instruction with specific concrete examples is better than either one alone (e.g., Cheng, Holyoak, Nisbett, & Oliver, 1986; Fong, Krantz, & Nisbett, 1986; Nesher & Sukenik, 1991; Reed & Actor, 1991). One of the most famous studies demonstrating this was performed by Scholckow and Judd (described in Judd, 1908; a conceptual replication by Hendrickson & Schroeder, 1941). They had children practice throwing darts at an underwater target. One group of subjects received an explanation of refraction of light, which causes the apparent location of the target to be deceptive. The other group only practiced, receiving no abstract instruction. Both groups did equally well on the practice task, which involved a target 12 inches under water, but the group with abstract instruction did much better when asked to transfer to a situation where the target was now under only 4 inches of water.

A variation on advocacy of apprenticeship training is advocacy for using only "authentic" problems (e.g., Brown, Collins, & Duguid, 1989; Lesh & Lamon, 1992). What is authentic is typically ill-defined but involves a strong emphasis on problems such as those students might encounter in everyday life. A focus on underlying cognitive process would suggest that this is a superficial requirement. Rather, we would argue, as have others (e.g., Hiebert et al., 1994), that the real goal should be to get students motivated and engaged in cognitive processes that will transfer. What is important is what cognitive processes a problem evokes and not what real-world trappings it might have. Often real-world problems involve a great deal of busy work and offer little opportunity to learn the target competences. For instance, we have observed in high school mathematics classrooms—where we have introduced longer, more real-world-like problems to situate algebra (Koedinger, Anderson, Hadley, & Mark, 1995)—that much of student time is spent on tasks such as tabling and graphing, which rapidly become clerical in nature. On the other hand, relatively little time is spent relating algebraic expressions to the real-world situations they denote.

To summarize: abstract instruction combined with concrete examples can be a powerful method. This method is especially important when learning must be applied to a wide variety of (frequently unpredictable) future tasks.

Claim 4: Instruction Needs to be Done in Complex, Social Environments

An elaboration of the previous position is the argument that learning is inherently a social phenomena. As Lave and Wenger (1991) argue:

> In our view, learning is not merely situated in practice—as if it were some independently reifiable process that just happened to be located somewhere; learning is an integral part of generative social practice in the lived-in world. (p. 35)

A second argument is that learning should be done on complex problems (e.g., Lesh & Zawojeski, 1992). These two ideas are put together in the proposal that learning should take place in complex, social situations with varying emphasis on the "complex" and the "social."[2] Although job training is only one function of education, this social + complex formula for learning situations is often justified with respect to preparing students for the workplace where it is argued they will need to display their skills in complex, social environments (Resnick, 1987).

While one must learn to deal with the social aspects of jobs, this is no reason why all skills required for these jobs should be trained in a social context. Consider the skills necessary to become a successful tax accountant. While an accountant must learn how to deal with clients, it is not necessary to learn the tax code or how to use a calculator while interacting with a client. It is better to train independent parts of a task separately because fewer cognitive resources will then be required for performance, thereby reserving adequate capacity for learning. Thus, it is better to learn the tax code without having to interact with the client simultaneously and better to learn how to deal with a client when the tax code has been mastered.

In fact, a large body of research in psychology shows that part training is often more effective when the part component is independent, or nearly so, of the larger task (e.g., Knerr et al., 1987; Patrick, 1992). Indeed, in team training, it is standard to do some part-task training of individuals outside the team just because it is expensive and futile to get the whole team together when a single member needs training on a new piece of equipment (Salas, Dickinson, Converse, & Tannenbaum, 1993). In team sports, where a great deal of attention is given to the efficiency of training, the time available is always divided between individual skill training and team training.

There are, of course, reasons sometimes to practice skills in their complex setting. Some of the reasons are motivational and some reflect the special skills that are unique to the complex situation. The student who wishes to play violin in an orchestra would have a hard time making progress if all practice were attempted in the orchestra context. On the other hand, if the student never practiced as a member of an orchestra, critical skills unique to the orchestra would not be acquired. The same arguments can be made in the sports context, and motivational arguments can also be made for complex practice in both contexts. A child may not see the point of isolated exercises but will when they are embedded in a real-world task. Children are motivated to practice sports skills because of the prospect of playing in full-scale games. However, they often spend much more time practicing component skills than full-scale games. It seems important both to motivation and to learning to practice one's skills from time to time in full context, but this is not a reason to make this the principal mechanism of learning.

While there may be motivational merit to embedding mathematical practice in complex situations, Geary (1995) notes that there is much reason to doubt how intrinsically motivating complex mathematics is to most students in any context. The kind of sustained practice required to develop excellence in an advanced domain is not inherently motivating to most individuals and requires substantial family and cultural support (Ericcson, Krampe, & Tesche-Römer, 1993). Geary argues, as have others (e.g., Bahrick & Hall, 1991; Stevenson & Stigler, 1992), that it is this difference in cultural support that accounts for the large difference in mathematics achievement between Asian and American children.

Another facet of the claim that instruction is best in a highly social environment comes from those claiming advantages for co-operative learning as an instructional tool (e.g., Johnson & Johnson, 1989). Cooperative learning, also known as "communities of practice" and "group learning," refers to learning environments where people of equal status work together to enhance their individual acquisition of knowledge and skills. This environment is to be contrasted with tutoring (in which the tutor and tutee are of unequal knowledge and status) and team training (in which the desired outcome is concerned with team or group performance). In a review by the Committee on Techniques for the Enhancement of Human Performance (Druckman & Bjork, 1994), it was noted that research on co-operative learning has frequently not been well controlled (e.g., nonrandom assignments to treatments, uncontrolled "teacher" and treatment effects), that relatively few studies "have successfully demonstrated advantages for cooperative versus individual learning," and that "a number of detrimental effects arising from cooperative learning have been identified—the 'free rider,' the 'sucker,' the 'status differential,' and 'ganging up' effects (see e.g., Salomon and Globerson, 1989)" (p. 95).

The NRC review of cooperative learning notes that there have been a substantial number of reports of "no differences" (e.g., Slavin, 1990) but unfortunately, there have also been a huge number of practitioner-oriented articles about cooperative learning that tend to gloss over difficulties with the approach and treat it as an academic panacea. Indeed, it is applied too liberally without the requisite structuring or scripting to make it effective. Cooperative learning must be structured with incentives that motivate cooperation and a sharing of the goal structure.

In colleges, we find group projects increasingly popular among instructors, but some of the difficulties encountered show that group learning can become counterproductive. Students sometimes complain about the difficulty of finding times for the group to meet to work on assignments together. The effort and difficulty of schedule coordination makes the practice frustrating. Further, some students complain that others exploit the system and assume that other partners in the group will do all the work (and hence acquire all the knowledge and skills). A reported practice among some students is to divide the labor across classes so that one member of a group does all of the work for a project in one class, while another carries the burden for a different class. Clearly these are not the intended outcomes of cooperative learning but are the sorts of things that will occur if there is not thoughtful implementation and scripting of the learning situation. We do not allege that cooperative learning cannot be successful or sometimes better than individual learning (see the National Research Council 1994 report, Druckman & Bjork, for discussion of issues involved in effective cooperative and group learning). Rather, it is not a panacea that always provides outcomes superior or even equivalent to those of individual training. The evidence shows, then, that skills in complex tasks, including those with large social components, are usually best taught by a combination of training procedures involving both whole tasks and components and individual training and training in social settings.

Summary

In general, situated learning focuses on some well-documented phenomena in cognitive psychology and ignores many others: while cognition is partly context-dependent, it is also partly context-independent; while there are dramatic failures of transfer, there are also dramatic successes; while concrete instruction helps, abstract instruction also helps; while some performances benefit from training in a social context, others do not. The development from behaviorism to cognitivism was an awakening to the complexity of human cognition. We have indicated in this paper some of the things that have already been discovered by cognitive research on the learning process and the implications of what we have learned for educational practice. The analysis offered by situated learning sometimes seems a regressive move that ignores or disputes much of what has been demonstrated empirically. What is needed to improve learning and teaching is to continue to deepen our research into the circumstances that determine when narrower or broader contexts are required and when attention to narrower or broader skills are optimal for effective and efficient learning.

We would like to close by acknowledging, as in the introduction, that situated learning has served a role in raising our consciousness to certain aspects of learning that were not fully appreciated in education. However, this consciousness-raising has had its negative aspects as well. Much of what we discussed in this paper were misguided implications for education drawn by the situated learning movement. It is not always clear that the original situated authors would endorse these implications. However, in the absence of disavowal from the cognitive science community, misguided practices can have the appearance of a basis in scientific research.

Notes

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[2]Although, interestingly, Lave and Wenger, in their book, explicitly abstain from making any educational recommendations based on this description of learning.

References

Anderson, J. R., Reder, L. M., & Simon, H. A. (1995). *Applications and misapplications of cognitive psychology to mathematics education.* Unpublished manuscript. (Accessible at http://www.psy.cmu.edu/~mm4b/misapplied.html)

Bahrick, H. P., & Hall, L. K. (1991). Lifetime maintenance of high school mathematics content. *Journal of Experimental Psychology: General, 120,* 22–33.

Bassok, M., & Holyoak, K. J. (1989). Transfer of domain-specific problem solving procedures. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 522–533.

Biederman, I., & Shiffrar, M. (1987). Sexing day-old chicks: A case study and expert systems analysis of a difficult perceptual learning task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 640–645.

Bjork, R. A., & Richardson-Klavehn, A. (1989). On the puzzling relationship between environment context and human memory. In C. Izawa (Ed.), *Current issues in cognitive processes: The Tulane Flowerree Symposium on Cognition.* Hillsdale, NJ: Erlbaum.

Boissiere, M., Knight, J. B., & Sabot, R. H. (1985). Earnings, schooling, ability, and cognitive skills. *American Economic Review, 75,* 1016–1030.

Bransford, J. D., Franks, J. J., Vye, N. J., & Sherwood, R. D. (1989). New approaches to instruction: Because wisdom can't be told. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 470–497). Cambridge, England: Cambridge University Press.

Brown, A. L. (1994). The advancement of learning. *Educational Researcher, 23*(8), 4–12.

Brown, A. L., & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (chap. 9) (pp. 229–270). Cambridge, MA: MIT Press.

Brown, A. L., & Kane, L. R. (1988). Preschool children can learn to transfer: Learning to learn and learning from example. *Cognitive Psychology, 20,* 493–523.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 34–41.

Carraher, T. N., Carraher, D. W., & Schliemann, A. D. (1985). Mathematics in the streets and in the schools. *British Journal of Developmental Psychology, 3,* 21–29.

Cheng, P. W., Holyoak, K. J., Nisbett, R. E., & Oliver, L. M. (1986). Pragmatic versus syntactic approaches to training deductive reasoning. *Cognitive Psychology, 18,* 293–328.

Cobb, P., Yackel, E., & Wood, T. (1992). A constructivist alternative to the representational view of mind in mathematics education. *Journal for Research in Mathematics Education, 23,* 2–33.

Collins, A., Brown, J. S., & Newman, S. (1989). Cognitive apprenticeship: Teaching students the craft of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453–494). Hillsdale, NJ: Erlbaum.

Druckman, D., & Bjork, R. A. (Eds.). (1994). *Learning, remembering, believing: Enhancing team and individual performance.* Washington, DC: National Academy Press.

Duncker, K. (1945). On problem-solving (L. S. Lees, Trans.). *Psychological Monographs, 58*(270).
Eich, E. (1985). Context, memory, and integrated item/context imagery. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11*, 764–770.
Elio, R. (1986). Representation of similar well-learned cognitive procedures. *Cognitive Science, 10*, 41–74.
Ericcson, K. A., Krampe, R. T., & Tesche-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*, 363–406.
Fernandez, A., & Glenberg, A. M. (1985). Changing environmental context does not reliably affect memory. *Memory & Cognition, 13*, 333–345.
Fong, G. T., Krantz, D. H., & Nisbett, R. E. (1986). The effects of statistical training on thinking about everyday problems. *Cognitive Psychology, 18*, 253–292.
Geary, D. C. (1995). Reflections of evolution and culture in children's cognition. *American Psychologist, 50*, 24–37.
Ghatala, E. S., Levin, J. R., Pressley, M., & Lodico, M. G. (1985). Training cognitive strategy monitoring in children. *American Educational Research Journal, 22*, 199–216.
Gick, M. L., & Holyoak, K. J. (1980). Analogical problem solving. *Cognitive Psychology, 12*, 306–355.
Gick, M. L., & Holyoak, K. J. (1983). Schema induction and analogical transfer. *Cognitive Psychology, 15*, 1–38.
Godden, D. R., & Baddeley, A. D. (1975). Context-dependent memory in two natural environments: On land and under water. *British Journal of Psychology, 66*, 325–331.
Greeno, J. G., Smith, D. R., & Moore, J. L. (1992). Transfer of situated learning. In D. Detterman & R. J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction* (pp. 99–167). Norwood, NJ: Ablex.
Hayes, J. R., & Simon, H. A. (1977). Psychological differences among problem isomorphs. In J. Castellan, D. B. Pisoni, & G. Potts (Eds.), *Cognitive theory, vol. 2*. Hillsdale, NJ: Erlbaum.
Hendrickson, G., & Schroeder, W. H. (1941). Transfer training in learning to hit a submerged target. *Journal of Educational Psychology, 32*, 205–213.
Hiebert, J., Wearne, D., Carpenter, T. P., Fennema, E., Fuson, K., Human, P., Olivier, A., & Murray, H. (1994, April). *Authentic problem solving in mathematics*. Paper presented at the meeting of the American Educational Research Association, New Orleans, LA.
Hunter, J. E., & Hunter, R. F. (1984). Validity and utility of alternative predictors of job performance. *Psychological Bulletin, 96*, 72–98.
Independent Commission on the Los Angeles Police Department. (1991). *Report of the Independent Commission on the Los Angeles Police Department*. Los Angeles, CA: Independent Commission on the Los Angeles Police Department.
Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research*. Edina, MN: Interaction Book Company.
Judd, C. H. (1908). The relation of special training to general intelligence. *Educational Review, 36*, 28–42.
Klahr, D., & Carver, S. M. (1988). Cognitive objectives in a LOGO debugging curriculum: Instruction, learning, and transfer. *Cognitive Psychology, 20*, 362–404.
Knerr, C. M., Morrison, J. E., Mumaw, R. J., Stein, D. J., Sticha, P. J., Hoffman, R. G., Buede, D. M., & Holding, D. M. (1987). *Simulation-based research in part-task training* (No. AF HRL-TR-86-12, AD-B107293). Brooks Air Force Base, TX: Air Force Human Resources Laboratory.
Koedinger, K. R., Anderson, J.R., Hadley, W.H., & Mark, M. A. (1995). Intelligent tutoring goes to school in the big city. In *Proceedings of the 7th World Conference on Artificial Intelligence in Education* (pp. 421–428). Charlottesville, VA: Association for the Advancement of Computing in Education.
Kotovsky, K., & Fallside, D. (1989). Representation and transfer in problem solving. In D. Klahr & K. Kotovsky (Eds.), *Complex information processing: The impact of Herbert A. Simon* (pp. 69–108). Hillsdale, NJ: Erlbaum.
Lave, J. (1986). Experiments, tests, jobs and chores: How we learn to do what we do. In K. Borman & J. Reisman (Eds.), *Becoming a worker*. Norwood, NJ: Albex.
Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life*. New York: Cambridge University Press.
Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, MA: Cambridge University Press.
Lehman, D. R., Lempert, R. O., & Nisbett, R. E. (1988). The effects of graduate training on reasoning: Formal discipline and thinking about everyday-life problems. *American Psychologist, 43*, 431–442.
Lesh, R., & Lamon, S. J. (1992). *Assessment of authentic performance in school mathematics*. Washington, DC: AAAS Press.
Lesh, R., & Zawojeski, J. S. (1992). Problem solving. In T. R. Post (Ed.), *Teaching mathematics in grades K–8: Research-based methods* (p. 49–88). Needham Heights, MA: Allyn and Bacon.
Nesher, P., & Sukenik, M. (1991). The effect of formal representation on the learning of rational concepts. *Learning and Instruction, 1*, 161–175.
Patrick, J. (1992). *Training: Research and practice*. San Diego, CA: Academic Press.
Pennington, N., Nicolich, R., & Rahm, J. (1995). Transfer of training between cognitive subskills: Is knowledge use specific? *Cognitive Psychology, 28*, 175–224.
Perkins, D. N., & Salomon, G. (1989). Are cognitive skills context-bound. *Educational Researcher, 18(1)*, 16–25.
Pressley, M., Borkowski, J. G., & Schneider, W. (1987). Cognitive strategies: Good strategy users coordinate metacognition and knowledge. In R. Vasta & G. Whilehurst (Eds.), *Annals of child development, vol.* 4 (pp. 80–129). Greenwich, CT: JAI Press.
Reder, L. M., & Klatzky, R. (1994) Transfer: Training for performance. In D. Druckman & R. A. Bjork (Eds.), *Learning, remembering, believing: Enhancing team and individual performance* (pp. 25–56). Washington, DC: National Academy Press.
Reder, L. M., & Ritter, F. (1992) What determines initial feeling of knowing? Familiarity with question terms, not with the answer. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 435–451.
Reed, S. K., & Actor, C.A. (1991) Use of examples and procedures in problem solving. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 17*, 753–766.
Reed, S. K., Ernst, G. W., & Banerji, R. (1974). The role of analogy in transfer between similar problem states. *Cognitive Psychology, 6*, 436–450.
Resnick, L.B. (1987). Learning in school and out. *Educational Researcher, 16*(9), 13–20.
Resnick, L. B. (1994). Situated rationalism: biological and social preparation for learning. In L. Hirschfeld & S. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture* (pp. 474–493). Cambridge, NY: Cambridge University Press.
Salas, E., Dickinson, T. L., Converse, S. A., & Tannenbaum, S. I. (1993). Toward an understanding of team performance and training. In R. W. Swezey & E. Salas (Eds.), *Teams: Their training and performance*. Norwood, NJ: Ablex.
Salomon, G., & Globerson, T. (1989). When teams do not function the way they ought to. *International Journal of Educational Research, 13*, 89–98.
Saufley, W. H., Otaka, S. R., & Bavaresco, J. L. (1985). Context effects: Classroom tests and context independence. *Memory & Cognition, 13*, 522–528.
Schoenfeld, A. H. (1985). *Mathematical problem solving*. New York: Academic Press.
Singley, M. K., & Anderson, J. R. (1989). *Transfer of cognitive skill*. Cambridge, MA: Harvard University Press.
Slavin, R. E. (1990). *Cooperative learning: Theory, research and practice*. Englewood Cliffs, NJ: Prentice-Hall.
Smith, S. B. (1986). *An analysis of transfer between Tower of Hanoi isomorphs*. Unpublished doctoral dissertation, Carnegie-Mellon University, Pittsburgh, PA.
Smith, S. M., Glenberg, A., & Bjork, R. A. (1978). Environmental context and human memory. *Memory & Cognition, 6*, 342–353.
Stevenson, H. W., & Stigler, J. W. (1992). *The learning gap: Why our schools are failing and what we can learn from Japanese and Chinese education*. New York: Summit Books.
Thorndike, E. L, & Woodworth, R. S. (1901). The influence of improvement in one mental function upon the efficiency of other functions. *Psychological Review, 9*, 374–382.
Vera, A. H., & Simon, H. A. (1993). Situated action: A symbolic interpretation. *Cognitive Science, 17*, 7–48.
Weisberg, R., DiCamillo, M., & Phillips, D. (1985). Transferring old associations to new situations: A non-automatic process. *Journal of Verbal Learning and Verbal Behavior, 17*, 219–228.
Woodworth, R. S. (1938). *Experimental psychology*. New York: Henry Holt & Company.

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