Instructional Design for Situated Learning

☐ Michael F. Young

The design of situated learning must be closely linked to the ecological psychology of "situated cognition," as exemplified by problem solving in a complex situated context, the Jasper Series. The extreme view of situated learning contends that all *thinking must be viewed as situated, and is therefore better explained by concepts of perception and action than by the concepts of information processing psychology. In this article, ideas of ecological psychology provide the background for describing four broad tasks for the design of situated learning: selecting the situations, providing scaffolding, determining and supporting the role of the teacher, and assessing situated learning. Further, three metrics for evaluating situated learning are suggested: affording transfer, providing meaning, and providing an anchor for cross-curricular investigation.*

☐ Brown, Collins, and Duguid (1989) have suggested that learning should take place in the context of realistic settings in which the reasons for learning sometimes repetitive or tedious procedures are made clear—an idea with roots tracing back to experiential learning (Dewey, 1938). Using what Brown et al. (1989) called "authentic tasks" enables students to immerse themselves in the culture of an academic domain, much like an apprentice tailor can be immersed in the culture of tailoring while only being responsible for ironing the garments finished by the master tailor. Brown et al. suggested that cognitive apprenticeships can be designed that immerse students in the culture of traditional academic domains such as mathematics, science, history, art, music, and languages. By being immersed in such realistic contexts, the need to learn certain repetitive or tedious skills is made evident, thus requiring less direct explanation by the teacher. The Cognition and Technology Group at Vanderbilt (1990, 1992) extended the ideas of cognitive apprenticeships by proposing macro-contexts (complex situations) that can "anchor" instruction in subjects across the curriculum. A recent commission designed to implement the nation's educational goals summarizes:

> We believe, after examining the findings of cognitive science, that the most effective way of learning skills is "in context," placing learning objectives within a real environment rather than

> insisting that students first learn in the abstract what they will be expected to apply. (SCANS, 1991, p. 4)

But if we are able to turn in our textbooks for realistic situations, a number of issues must first be addressed. How should the situations be selected or designed? How can we tell good situations from bad ones? What kinds of tests will we use?

THE NATURE OF SITUATED LEARNING AND SITUATED COGNITION

The most extreme position on situated learning contends that not only learning but thinking itself is situated and hence must be viewed from a ecological psychological perspective. This framework draws heavily from the work of James Gibson (1979/1986), emphasizing perception rather than memory as the means by which we learn. In contrast to schema theories in which meaning is stored and retrieved from memory, meaning in situated cognition is generated on the spot through perceiving and acting (e.g., Clancey & Roschelle, in press). In the situated cognition model, the processes of perceiving and acting create meaning "on the fly," rather than reading it back from something (representation or schematic) stored in the head. From this view, remembering arises through interactions with the environment, and the concept of memory becomes nonexistent or irrelevant to an explanation of knowledge and learning, replaced by an emphasis of the tuning of attention and perception; that is, perceptual learning.

From the perspective of situated cognition, there are always two components to learning: the agent and the context. Knowledge and intelligence must be viewed as the relationship between the actor (effectivities/abilities) and the environment (information specifying particular affordances)—a symmetry of acausal interactions (Shaw, Turvey, & Mace, 1982). It would be misleading at best to assert that the properties of the domain, the problem space, or the learning context merely influence thinking. For example, it is the relationship between the agent and the problem that *is* problem solving. It would not be meaningful to characterize the problem solving of an individual apart from the context in which that problem solving occurs. A situated cognitive analysis of thinking must describe both the abilities of the problem solver and all the relevant attributes of the environment perceived by the problem solver, including dimensions of the problem and problem space that afford certain actions. In the equal emphasis of environment and agent, situated cognition represents more than Skinner's (1987) impoverished emphasis on the context, antecedents, and consequences of actions. Situated cognition asserts that not just anything in the environment that causes a reaction is a stimulus, but rather it is the information picked up from the environment that we must understand and use instructionally.

Greeno, Smith, and Moore (in press) address the interactive nature of cognition as they undertake to characterize transfer from a learning situation to a novel situation, using the situated learning model. They write that an activity like problem solving

> . . . jointly depends on properties of things and materials in the situation and on characteristics of the person or group. Following Gibson (1979/1986) and Shaw et al. (1982) . . . affordances and abilities are relative to each other: a situation can afford an activity for an agent who has appropriate abilities; and an agent can have an ability for an activity in a situation that has appropriate affordances. (p. 4)

Thus, from the perspective of situated cognition, it would be just as accurate (or inaccurate) to classify environments as gifted or retarded as it is to characterize the agents who operate in those environments in those terms. However, classifying individuals or environments in such terms is inappropriate from a situated cognition perspective, since the entire interaction is always dynamic. Students interact differently in different situations, and even in similar environments students' changing goals and intentions make the situations different. In fact, it is only the interaction between an agent and an environment that can truly be said to be intelligent.

Vicente and Harwood (1990) explained the role of context by referring to Simon's (1981) allegory regarding an ant on a beach:

> Viewed as a geometric figure, the ant's path is irregular, complex, and hard to describe. But its complexity is really a complexity in the surface of the beach, not a complexity of the ant. (p. 64)

The ant's behavior is constrained by the landscape of the beach more than by internal organismic forces. When the ant is placed on a different part of the beach or when external disturbances (e.g., wind, earth movement) occur, different navigation actions are required to reach the same goal. Different ants may have different strategies for navigation that are used depending upon the type of disturbance experienced. Vicente and Harwood (1990) suggested that understanding such a situated activity requires the determination of (a) regularities in the ways the landscape affects the ant, and simultaneously (b) the psychological invariance of the ant across different tasks.

For situated cognition which has social/cultural components, potential invariants of the agent include goals and intentions, and potential regulation includes information contained in the environment, especially other people who provide mutual affordances for each other (e.g., cognitive apprenticeship, Brown et al., 1989; reciprocal teaching, Brown & Palinscar, 1988; distributed intelligence, Pea, 1988; external memory, Wegner, 1987).

Situated cognition requires a radical redefinition of learning, thinking, and what it means to be intelligent. With the emphasis not on memory but on perception, knowledge is no longer simply something stored in the head; rather, it is an interaction in a specific context in which "intelligent" activity is meaningful and appropriate. Lave's (1988) work on everyday cognition highlights the importance of context (situations) to a description of thinking. Lave describes how "just plain folks (JPFs)" use mathematics, think differently, and solve problems in everyday settings that they cannot solve in classroom settings. Context broadly includes people, machines, design artifacts, environments, and other objects and agents that may interact to establish ecological problem-solving relationships. But context also includes a shared culture, understanding, and motivations. In order to even detect expert knowledge, let alone instruct or teach it, it is necessary to have a student actively engaged in some important complex realistic (authentic) activity. In one important instance when the student's environment includes other people (teachers), knowledge is often constructed through communication (Greeno, 1992). A situated learning redefinition of knowledge, then, contends that knowledge is an active relationship between an agent and the environment, and learning must take place during the time the student is actively engaged with a complex, realistic instructional context.

THE DESIGN OF SITUATED LEARNING

Beyond simply using authentic tasks occasionally in classrooms, some have argued that *all* learning must be understood as situated in realistic contexts (e.g., Bereiter, 1991; Greeno et al., in press). But if all learning is situated, then part of the attributes of the situation for most traditional instruction is a classroom, where learning is competitive among individuals, the subject and nature of problems change on the hour in a predictable succession, and the major, if not only, source of information is one person: the teacher. This is not a context that transfers to many situations outside the educational system. In most other contexts in which academic subjects are applied, there is usually one big problem to solve (such as NASA's problem of how to put men on Mars) and many related smaller problems in service to this superordinate goal (such as engineering the rocket, issues of human physiology on a long space flight, planning for food and fuel, and the physics of trajectories and rendezvous). Further, the information for solving these problems is distributed across many individuals and only through collaboration and coordination can solutions be found. To meet the test of "authenticity," situations must at least have some of the important attributes of real-life problem solving, including ill-structured complex goals, an opportunity for the detection of relevant versus irrelevant information, active/generative engagement in finding and defining problems as well as in solving them, involvement of the student's beliefs and values, and an opportunity to engage in collaborative interpersonal activities (Young &

McNeese, in press). This is the nature of learning that takes place in everyday situations (Lave, 1988).

Consider three examples of real-world problem solving: the surgeon during an operation, an Air Force pilot acquiring targets while flying an F-15 fighter jet, and a design team developing a new idea with the aid of computer design tools. The knowledge in these situations is not static and not solely contained within the individual(s) involved. The "knowledge" is distributed throughout the environment, in computers, books, patient monitors, cockpit instruments, and especially other people: what Pea (1988) called "distributed intelligence." The heart monitors, airplane avionics, and computer design programs for these real-world problem solvers all provide information while continually signalling new problems (and subproblems) and changing conditions. There is also teamwork involved, with experts in different domains collaborating to solve a problem that no one specialist could solve alone: what Brown and Campione (1990) have referred to as "the social construction of knowledge." In addition, each individual's goals, values, and beliefs interact with these distributed sources of information, so that each person's experience in the situation is unique.

There are four critical tasks involved in instructional design for situated learning. The first task is the selection of the situation or set of situations that will afford the acquisition of knowledge that the teacher wishes each student to acquire—selection of the proper "generator set" (Shaw et al., 1982). The second task is to provide the necessary "scaffolding" for novices to operate within the complex realistic context and still permit experts to work within the same situation (see for example, Bruner, 1986; Vygotsky, 1978). With the role of the teacher reconceptualized into more the role of coach (Collins, 1991), the third task of design for situated learning is to provide supports that enable teachers to track progress, assess products, access distributed sources of knowledge, interact knowledgeably and collaboratively with individual students and/or cooperating groups of students, and develop their own skills in utilizing specific situations and situations in general (teacher preparation and enhancement). The final task for the design of situated learning is to define the role and nature of assessment and what it means to "assess" situated learning.

On the issue of selecting situations, Greeno et al. (in press) point out that multiple situations are really needed for students to acquire the general, abstract knowledge that is essential to mathematical and scientific thinking. The Cognition and Technology Group at Vanderbilt (1990, 1992) also acknowledged the need to provide an intelligently selected and sequenced set of situations (in its Jasper Series, pairs of related adventures) that provide students an opportunity to detect the components of their solutions that are invariant across an entire class of problems. But little research is available to guide us in selecting the proper "generator set" of situations that will enable students to learn algebra or political theory or any of the traditional classroom subjects. From work on pattern recognition, general principles can be suggested, such as providing a contrast set (examples and non-examples) and progressing from large differences to finer and finer distinctions. But these results come primarily from use of static displays rather than the complex, interpersonal environments of realistic problem-solving situations. Gibson (1979/1986) suggested that our perceptual systems are designed to detect invariance and will do so readily if given an opportunity. The designer's first task is to select the generator set of situations (complex, realistic problem spaces) that afford students the best opportunity to detect the stable (invariant) concepts of traditional subject domains.

On the issue of providing scaffolding, situated learning recommends that students be active generators of both problems and solutions, allowing each student to "crisscross the landscape of knowledge" rather than take a linear trip down a single path that has been predefined by an instructional designer (Spiro, 1991). Allowing students to define their own constraints on the learning environment does not imply complete freedom or aimless exploration. Rather, like the apprentice tailor assigned only to ironing finished garments, activities can be defined within a broader context that provide scaffolding for a novice within an environment. Soloway (1991) provides a good example of scaffolding when his PASCAL programming learning tool makes certain options unavailable to novices until they have completed important, but perhaps less obvious steps, such as goal planning and pseudocoding. The concept of scaffolding is directly related to the amount of learner control afforded by the learning context. But rather than program control or advisement from the designer (e.g., Tennyson & Buttrey, 1980), scaffolding refers to a process of initially limiting a novice's access to all the features of the context and then removing those constraints as soon as possible. The issues for instructional design, then, are what scaffolding to provide for each situated learning context and how quickly it can be removed as students move from novice to expert performance.

On the issue of supporting the teacher's role in situated learning, it must first be cautioned that for the situated learning perspective, teaching is a role played only in part by people (like traditional teachers) in the student's environment. The learning environment itself plays a part in teaching by affording (or not affording) certain important actions to be learned. Some teaching is also done by other students, who provide mutual affordances to one another. Also, students involved in situated learning teach themselves as their perceptual systems detect changes, analyze environments, produce actions (changes in the environment), and "learn" by detecting invariance across situations. From the situated learning perspective, then, teaching can be directed by any of the varied sources of distributed knowledge described by Pea (1988), including but not limited to the teacher.

Looking solely at the role played by an experienced adult operating within the situated learning environment (like a traditional teacher), teaching becomes not easier but significantly harder. Individual student differences (effectivities of the agents such as beliefs, goals, and values) must not only be considered, but are essential for understanding situated learning. Therefore, a teacher using situated learning must be constantly assessing the perception-action interaction of each student, and/or the combined actions of cooperating groups of students operating within the situation. This monumental task can only be accomplished with supports provided by other adults or equivalently clever technology. Without such aids, practical implementations of "cognitive apprenticeships" (Collins, Brown, & Newman, 1989) will be scant.

Although there will be value in students seeing their teacher as an experienced novice operating in a new domain, most often the teacher will need and want to be experienced with the situation and, therefore, able to direct the attention of students to important attributes of the environment. Teachers who are comfortable with risk taking, and who are willing to turn over some control of the learning environment to students, have succeeded in working along with students as "experienced novices" in mathematical problem solving. But such an approach increases the complexity of the teaching task, even beyond the teaching challenge associated with focusing on higher level thinking skills in the context of realistic problem solving. From the perspective of situated cognition, the teacher's role should be to "tune the attention" of students to the important aspects of the situation or problem-solving activity, specifically those attributes that are invariant across a range of similar problems and therefore will transfer to many novel situations. This can be achieved as teachers work along with students on a novel problem (a recommended aspect of cognitive apprenticeship; see Collins et al., 1989), but is probably best achieved when teachers are very familiar with the problem/solution space being used for instruction.

One initial solution, then, would be for teacher training itself to be situated, including both domain-specific training (math, science, language, social studies) as well as techniques of pedagogy, classroom management, and (situated) instructional design. Situated teacher training would involve using classroom situations in which students are engaged in situated learning, and actively engaging preservice teachers in solving the problems or designing and implementing situated learning (e.g., Collins & Brown, 1988). Another possible solution is to provide "job aids" for teachers implementing situated learning. Such technology would at least need to provide storage and retrieval of common misconceptions, "bugs," malrules," and preconceptions (p-prims; see diSessa, 1983) being used by students in a particular situation, and possibly the characteristic errors or planning paths that are indicative of such misconceptions. Technology-rich situated learning may allow continuous assessment of student/group progress through the solution space of a given situation, freeing the teacher to serve in the role of mentor/coach rather than lecturer/grade-giver. Finally, the combination of databases of common errors and embedded assessment may, in the long run, afford the development of intelligent suggesters for particular situations that can undertake some of the monitoring and coaching required to tune the attention of students engaged in situated learning.

Assessment of Situated Learning and Anchored Instruction

As the nature of instruction changes to be more collaborative, situated, and distributed in its sources of information, traditional means of assessment will quickly prove inadequate. Multiple-choice items that assess the static factual knowledge of students must be replaced by cognitive tasks and assessments that can focus on the processes of learning, perception, and problem solving. In addition, assessment can no longer be viewed as an add-on to an instructional design or simply as separate stages in a linear process of pretest, instruction, posttest; rather, assessment must become an integrated, ongoing, and seamless part of the learning environment. More than formative and summative evaluation, the entire instructional design process must be changed from a serial stage model in which assessment enters and leaves, toward a model in which the processes that serve as instructional stimuli also serve to provide data to a psychometric model. Seamless assessment could then provide important feedback to both teacher and student, and perhaps even be instantiated as a partner or "knowledge navigator" in the process of learning. In short, design techniques for situated learning must encourage the construction of instruction and assessment as one (see Snow & Mandinach, 1991).

Assessment must not only be integrated with instruction, but must focus on the learning process as well as the learning products (Case, 1985). When learning changes from direct instruction to situated learning, the assessment of successful and less successful learners (or experts and novices within a domain) must change from an emphasis on right/wrong responses toward an emphasis on the information that each student perceives in the situation(s). The affordances that each student perceives can be detected by the types of information to which they attend (e.g., video scenes replayed), the paths taken toward solution (solution spaces), the types of analogies and transfer that occur, and the types of errors (misconceptions or malrules) that are made. These new sources of data will require new and more elaborate (multivariate, nonlinear) psychometric models. In short, as instructional design models are adapted for situated learning with technology, the assessment components will need to be radically different. Assessment should be a seamless, continuous part of the activity (a learning/assessment situation), enabled by technology and complemented by innovative psychometric techniques.

METRICS FOR SITUATED ENVIRONMENTS

Not all situations afford learning to the same degree. For example, sitting alone in a closet is certainly a situation, but it is not a situation that affords learning much about algebra or chemistry, nor does it afford learning much about playing tennis or riding a bicycle. Once a proper generator set of situations has been determined, the teacher or instructional designer must adopt some criteria for determining whether they afford the conceptual or procedural learning desired. Three suggestions for the type of evidence one should look for in a situation for learning are: (a) the ability to afford transfer to targeted concepts or procedures, (b) the ability to provide meaning for learning, and (c) the ability to accommodate "anchored instruction."

Transfer

If the design task for situated learning is to select the proper generator set of situations that will precisely afford students the best opportunity to tune their attention to the important invariants of a subject area (as suggested above), then the true test for successful learning is transfer of learners' skills from the situations in which they are learned to novel situations in which the relevant knowledge could also be applied. Near and far transfer situations as well as situations that afford the use of both domain-specific knowledge and higher-order skills (planning, discriminating the relevant from the irrelevant, metacognitive monitoring of progress, etc.) would constitute the range of transfer situations needed to determine successful learning. In fact, as discussed in the next section, such a determination could be made continuously using dynamic assessment techniques that are completely integrated into the initial generator set of situations. In that case, the generator set would need to be constituted broadly enough to incorporate near and far transfer opportunities.

Meaning

When Brown et al. (1989) discussed situated cognition and cognitive apprenticeships, they relied heavily on real-world apprenticeships (e.g., apprentice tailors) as the model for their analysis. While real-world experiences are perhaps the best situations, classrooms (as currently constituted) cannot provide or utilize many such situations. Some classes are fortunate enough to be able to take instructional advantage of trips to zoos, museums, aquariums, and research institutions, but few are able to take advantage of many such events during the school year. The hallmark of such events is the meaning they provide to students for subsequent study of biology, history, chemistry, and mathematics, etc. (see, for example, cognitive apprenticeships; Collins et al., 1989). Immediately after a trip to the zoo, students typically have little trouble answering the question, "Why are you learning about evolution?" The answers are often, "So I can become a zoo keeper" or "To understand how frogs we saw yesterday came to be the way they are." But rarely did I get such meaningful answers when I asked students in my traditionally taught Algebra II class why they were learning logarithms; their answers tended toward, "Because we have to" or "To get a good grade." As designers begin to construct learning situations with the aid of technology, one essential standard should be the meaning students attach to their activities and interactions within those environments. Students should be able to provide meaningful goals when asked, at any point, why-questions such as, "Why are you performing that action?" or "Why is your group researching that issue?"

Anchor Situations

"Anchored instruction" is a term coined by the Cognition and Technology Group at Vanderbilt (1990) to describe a special type of situation for learning. Consider that it is possible to situate learning in two ways. The first is exemplified by many law school courses on tort law, where a separate real-world case is used to explain each new dimension of law. In this tradition, it is possible to encounter several cases in a single course lecture. Such situations can be considered micro-contexts for each specific topic to be learned. In contrast, it is also possible to select "macro-contexts" that are sufficiently rich and complex to be meaningfully viewed from several perspectives. The Vanderbilt Group describes the use of a feature-length film, *Young Sherlock Holmes*, to anchor a semester-long investigation of Victorian era history; scientific concepts such as weather, geography, and inventions; and literature, including story grammars, vocabulary, and readings related to the context. The use of a single film for an entire semester might, at first blush, invoke images of students bored to tears when viewing the film for the tenth or thirtieth time. But learning new perspectives of material that students initially thought they understood completely proved to be challenging and motivating to students. It was the changes in understanding that proved motivating, not the original presentation of the situation. This is the evidence of a successful situated learning event—it serves as an anchor for multiple perspectives, all equally valid and fully justifiable within the context of the situation.

THE JASPER SERIES: ONE EXAMPLE OF SITUATED LEARNING

The Jasper Series* was designed as an instructional environment in which to investigate the emerging issues of situated learning. Briefly, instruction using the Jasper macrocontext involves viewing a series of 15-minute videodisc-based stories in which the major character, Jasper Woodbury, encounters a problem such as the discovery of a wounded eagle far out in the woods. All of the data required to obtain a quantitative solution to the rescue of the eagle have been embedded in the story. Students are challenged to list all of the things they must consider to develop a workable rescue plan (e.g., time, payload of the rescue plane, fuel, etc.). They are then asked to generate and document their solutions. Throughout this time, the videodisc is made available for students to retrieve relevant facts and information on request, often accessing the disc themselves using a Hypercard® interface or hand-held controller.

Each episode in the series presents a complex multi-step problem that students typically require more than a week of traditional 40-minute classes to solve, either individually, in small groups, or as a class. There are currently four episodes available, with plans for six episodes in the complete series. The random-access capability of the videodisc makes the complexity of these problems manageable, since quantitative facts as well as story events can be quickly and easily reviewed. Even though the mathematics required to solve the physics distance/rate/time problems of the Jasper episodes are important in a real-world sense, the computations themselves are not complex, and students are often challenged more by the process of dealing with the multi-step nature of the problem rather than by the mathematics involved (for discussion of such difficulties see Campione, Brown, & Connell, 1988). Practice in dealing with complexity can develop in students an appreciation of the need to plan, the ability to retrieve relevant information when needed, skills in metacognitive monitoring of progress toward solution, and an appreciation that not all mathematics problems can be solved quickly, even when the required computations are not in themselves complex (such skills are often called higher-order thinking skills).

The Cognition and Technology Group at Vanderbilt (1992) have described seven design principles underlying the Jasper Series. They include a video-based format, a narrative structure, generative problem solving by the user, all the data needed for quantitative solutions being embedded within the story, purposeful complexity, pairing of stories to afford transfer, and enhancement of the narrative with links across the curriculum. These principles address the first of the four design tasks outlined above, selecting (designing) a situation. However, they do not suggest the other three design tasks for situated learning: what scaffolding to provide to problem solvers of different ability, how to support and develop the teacher as coach and mentor, or the issues of assessing students' problem solving.

Jasper as a Generator Set

As described by The Cognition and Technology Group at Vanderbilt (1992), the Jasper episodes have been designed to afford perception of invariance in the form of physics and mathematical "mid-level" concepts (diSessa, 1988), such as distance/rate/time and area/volume. The episodes are sequenced to provide oppor-

---

*The "Jasper Series" is commercially available from Optical Data Corporation. The series was developed by the Learning Technology Center, Peabody College, Vanderbilt University, John Bransford and Susan Goldman, co-directors.

tunities for near transfer of mid-level concepts between pairs of videodiscs, and far transfer of higher-level planning and information-finding skills across pairs of videodiscs.

Scaffolding for the Jasper Series

A HyperCard® stack designed to assist Jasper problem solvers has been developed and is currently the focus of instructional and assessment research (Figure 1). The Jasper Planning Assistant (JPA) provides videodisc control, a calculator, and a place to record related facts (Young & Kulikowich, 1992b). Perhaps more importantly, the JPA also provides scaffolding for navigating through the complex solution space for the Jasper problem. Student calculations cannot be recorded on the system without a related planning question first being generated. The JPA provides a menu-selection page to assist problem solvers in developing the required planning questions (see Figure 2). In this way, planning is prompted throughout problem solving, and novice problem solvers are afforded additional information for planning. The resulting planning questions also externalize the problem-solving goals of the students, something often missing or only implied by verbal think-aloud protocols of problem solving.

Teaching with Jasper

The Cognition and Technology Group at Vanderbilt (1992) described three models for teaching with the Jasper materials they developed: (a) basics first, immediate feedback, direct instruction; (b) structured problem solving; and (c) "guided generation." In this description, the authors support the guided generation model as being more powerful than the other two, without outright endorsement of this approach. The guided generation approach as described by the Vanderbilt Group involves teachers providing scaffolding to aid the more novice problem solvers among their students. But instructional designs for situated learning must not only provide scaffolding for students; they must also provide scaffolding for teachers, to aid them in under-

FIGURE 1 ☐ Component Screens of the JPA

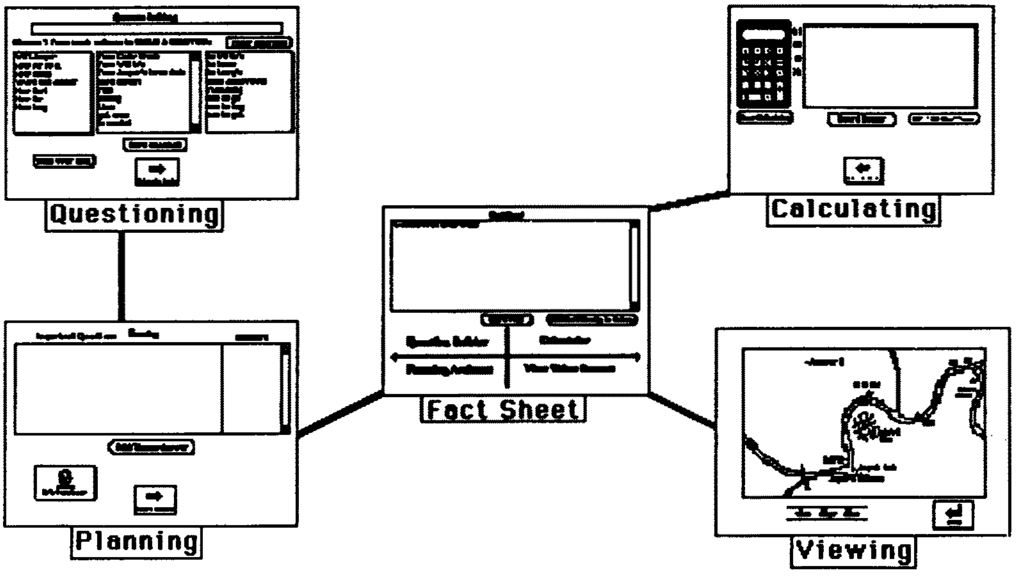
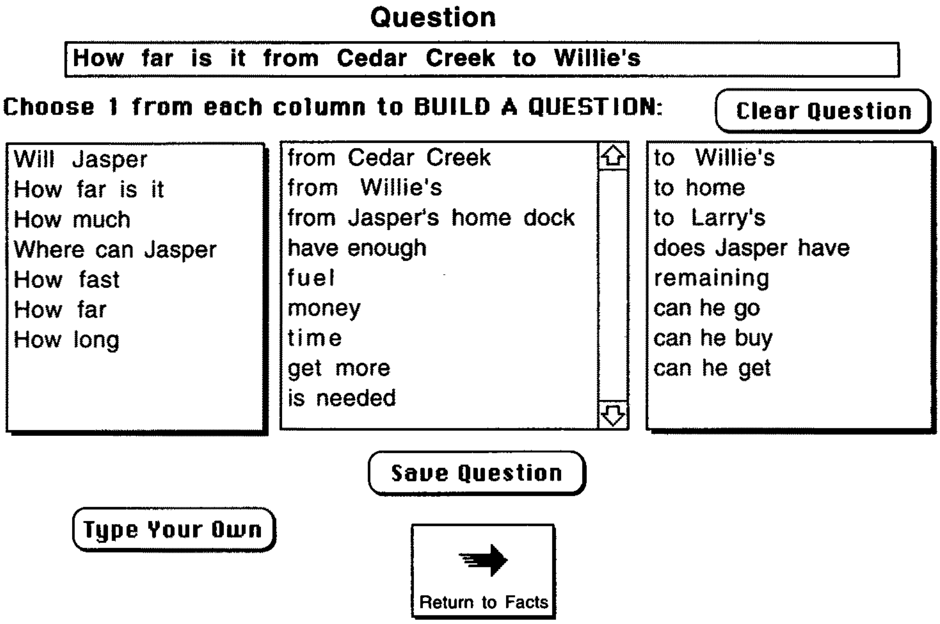


FIGURE 2 ☐ Menu Selection Page of the JPA



Question

How far is it from Cedar Creek to Willie's

Choose 1 from each column to BUILD A QUESTION:

taking the guided generation approach to teaching.

While no intelligent technology implementations currently exist, a number of preliminary steps have been taken toward facilitating the role of Jasper teacher as coach. First, HyperCard® controllers have been developed to facilitate retrieval of information from the videodisc. These controllers map the time sequence of story events onto a spatial map of the locations at which events occurred. The controllers free teachers from controlling the videodisc and allow them to concentrate on student thinking and problem solving. Second, videodisc-based segments of Jasper classrooms afford first-time Jasper teachers an opportunity to experience some of the misconceptions and errors that students typically make in solving the Jasper problems. Third, strategies and ideas can be disseminated among teachers, through both online telecommunications and more conventional means, a Jasper newsletter. Fourth, through telecommunications links with participating universities, it is envisioned that Jasper teachers and students could contact "Jasper" directly, with the simulated "Jasper" responses supplied by preservice teachers enrolled in courses focusing on situated learning.

Finally, a microanalytic analysis of Jasper problem solving, adapted from Chi & Koeske (1983), Shoenfeld (e.g., Shoenfeld, Smith, & Arcavi, in press) and diSessa (1983), revealed in detail the nature of common misconceptions associated with the Jasper situation. In this microanalysis, videotapes, interviews, think-aloud protocols, and traditional tests were used to document the genesis of conceptual changes during problem solving with the first two Jasper episodes. For example, it was revealed that some Jasper problem solvers assumed that large boats traveled at the same rate as smaller boats, even when traveling with a current rather than against it. Another misconception for fifth-grade students in this analysis was that a mile was shorter if traveled at a fast speed and longer when traveled slowly (confusing time with actual distance traveled). In addition to documenting common errors, the microanalysis highlighted some of the student abilities (effectivities) tapped by the Jasper problem, including the ability to map time onto a spatial array (to use a videodisc map controller), the ability to mathematically operationalize the problem, and the ability to verbalize mathematical operations and results of calculations (to participate in collaborative problem-solving groups). All these techniques, some technology-supported, others empirical, have yielded information to aid teaching in this one particular situation, the Jasper problem. It is argued here that similar efforts will be required for each new design of situated learning.

Jasper and Transfer

If, as suggested above, the first metric of successful situations is transfer, then the Jasper Series, while yet unproved, has begun to collect the appropriate evidence. Initial research on Jasper suggested that transfer does occur to completely isomorphic problems in a different context (e.g., Mary goes to the grocery store versus Jasper goes to buy a boat). Further evidence of transfer has also been demonstrated from situated Jasper problem solving to traditional one- and two-step word problems (Van Haneghan et al., 1992). A final piece of evidence is provided by the demonstration of transfer from the mathematical domain of the Jasper problem to reading comprehension for passages with analogous content (Young & Kulikowich, 1992a). These preliminary results have taken considerable research effort to acquire, suggesting that evaluating situations for learning will not be a simple or quick task.

Jasper as Meaningful Learning

The microanalysis of Jasper problem solving mentioned above revealed that, when asked *why* they are working in class, students often referred to the meaningful nature of the Jasper context to justify their mathematical operations. For example, when asked why he was performing the calculation 65 × 2 (65 miles from the veterinarian's to the injured eagle, times 2 for a round trip), one low-achieving, street-wise fifth-grader responded, "To make sure they can get the injured eagle to the vet. The gunshot wound will be bleeding and they need to worry about infection." This use of knowledge which is (unfortunately) part of this student's everyday experiences indicates that problem solving in the Jasper context is activating everyday cognition, as opposed to traditional "inert" school knowledge (for a discussion of inert knowledge, see Whitehead, 1929). In this case the mathematics is meaningful, not simply something done for a grade or because a teacher requests it.

Jasper as Anchored Instruction

A recent implementation of the Jasper Series in a suburban Connecticut middle school demonstrated the capability of the Jasper situations to anchor instruction across the curriculum. Students engaged in solving the first Jasper episode, situated as a river trip, used the situation as an anchor for science and social studies, as well as the central mathematics problem. Pairs of students designed river-related science questions, such as: How much inorganic matter can be observed in the Connecticut river? What microscopic organisms can be observed in water samples? What types of birds can be observed on the Connecticut river? Then the students were taken on a one-hour river trip on which they performed their science experiments. Students wrote essays about their results and presented their findings. One pair of students was so convinced of the importance of their findings about the numerous bottles and cans floating in the river that they submitted their essay to the executive committee responsible for running the local triathlon, which included a swimming race in the river. In social studies, students drew maps to locate the equivalent locations on their local river (e.g., mile 132.6 on the Connecticut River) for mile markers mentioned in the Jasper problem. The same group of students studied flight and participated in a balsa wood plane competition when solving the second Jasper episode involving the rescue of a wounded eagle using an ultralight airplane. These selected examples suggest that, in addition to affording transfer and providing meaning, the Jasper situations can also serve as anchors for instruction across traditional subject areas.

Situated Jasper Assessment

In the context of Jasper problem solving, Kulikowich and Young (1991) have outlined the advantages of using an automated data retrieval system, the Jasper Planning Assistant, to complement verbal protocol analysis. (For a description of verbal protocol analysis in the Jasper context, see Van Haneghan et al., 1992.) The automated system provides both scaffolding for instructing novice problem solvers (planning, questioning, calculating, and retrieving data; see Figure 1) and process data that can service a psychometric model, including planning statements, operating facts, information retrieved from the problem, latencies for each of these activities, and attitude and interest measures (see Figure 3, particularly data summary at bottom).

Young and Kulikowich (1992b) give details of the JPA in use as both scaffolding for planning during instruction and collector of information for assessment. Students use the JPA individually or in pairs. At first, JPA presents a tutorial and several Likert-type items to assess interest and self-efficacy. Next, JPA displays the Jasper story and assesses selected information perceived by the student using a series of multiple-choice questions. JPA then requires the student to initially create four planning questions before attempting to solve the Jasper problem (thus providing scaffolding for planning). Students are then encouraged to enter all the facts they can recall from the video or subsequently retrieve by re-viewing the video. JPA includes an interface to the videodisc that enables it to control the video upon request, and to store the frame numbers of video segments re-viewed by the student. Output data from the JPA enables interpretation of various problem-solving events, as well as specific analyses of time spent on planning, questioning, reviewing facts, watching the video, and making calculations. (JPA output and interpretation are shown in Figure 3.)

The JPA system can complement other assessment techniques in several ways (Kulikowich & Young, 1991). Think-aloud protocols can be supported by data collected during problem solving by the JPA, or JPA output can serve as the stimulus for problem solvers to explain what they did as they worked through the problem (as in Figure 3). This later approach has proved valuable for assessing the problem solving of both individuals and pairs. Information collected during problem solving through the JPA can also help to interpret transfer of situated learning from the Jasper context to analogous content in reading passages, assessed by traditional paper-and-pencil tasks (Young & Kulikowich, 1992b).

The ecological psychology from which situated learning draws much of its theoretical basis suggests that Jasper assessment must be targeted at detecting the affordances that each student perceives while working in the Jasper context. This may be possible with the aid of several types of JPA output, including the types of information to which students attend (Jasper video scenes replayed), the paths taken toward solution (solution spaces), the types of analogies and transfer that occur (assessed by transfer tasks), and the types of errors (misconceptions or malrules) that are made (assessed by microanalysis, interviews, and video records). These new sources of data may require interpretation through the nonlinear dynamics models currently employed by ecological approaches to direct perception and action.

SUMMARY AND CONCLUSION

There is a growing consensus that significant educational changes are required in order to meet the nation's educational goal to make American students number one in mathematics and science. In concert, there is a growing awareness that situating learning in realistic contexts can provide much of what is lacking in traditional approaches to instruction and instructional design. These insights rely heavily on the concepts of situated cognition for their justification, which, in turn, rely heavily on the ecological psychology of James Gibson (1979/1986). Once the important role

FIGURE 3 ☐ Sample JPA Output with Interpretation

```
              JPA Output                                   Interpretation by Experimenter

Student: A. A.   Starting 8/19/92   Time in: 11:38:42 AM

1. Tutorial
2.
Instructions

Facts                                  12:06:07 PM        Estimating Mile Markers
Video                                  12:06:20 PM

Facts                                  12:07:18 PM        Entering Facts
  Add Fact: from 129 to 157 12:07:46 PM

Calculating                            12:07:51 PM        Calculating (distance)
Calc: 157  -  129  =  28                                   (error)

Questioning                            12:08:36 PM
Planning                               12:08:36 PM        Entering Answer
Facts                                  12:08:47 PM
 ANSWER: How far from Cedar Creek to home? = 28 miles

Planning                               12:09:06 PM
Facts                                  12:09:16 PM
Video                                  12:09:18 PM        Info Finding (speed, 7.5)
..V:  1 Mile Test
Facts 12:10:18 PM

Calculating                            12:10:32 PM
Calc: 28  *  7.5  =  210                                  Calculating (time)
Calc: 210  /  60  =  3.5

Planning                               12:11:57 PM
Questioning                            12:12:58 PM        Entering Answer
Planning                               12:12:58 PM
 Q: How far is it from Cedar Creek to home?  12:13:21 PM
 ANSWER: How far is it from Cedar Creek to home? = 3.5 minutes   (error)

Planning                               12:13:28 PM        Correcting Units
  Change Answer 6 to 3.5 hours


Facts                                  12:14:21 PM
Video                                  12:14:23 PM
..V:  Map                                                 Info finding (T sunset)
..V:  Boat Leaving
Facts                                  12:16:32 PM
  Add Fact: sunset is at 7:52          12:16:59 PM

Video                                  12:17:02 PM        Info finding (T current)
..V:  Jasper Thinks
Facts                                  12:18:10 PM
  Add Fact: he is ready to leave at 2:35   12:18:29 PM

Calculating                            12:18:34 PM
Facts                                  12:19:42 PM        Calculating (T available)
Calculating                            12:20:22 PM
Calc:      5.2  =  5.2

... Output Continues ...

Summary Data:
Total Time Planning: 570,      Total Time Questioning: 357,   Total Time Facts: 807,
Total Time Calculating: 491,   Total Time Viewing: 1043
Rated Math Efficacy: 77,       Rated Computer Efficacy: 78,
Rated River Interest: 52,      Rated Horse Interest: 26,
Rated Confidence in Solution: 84

Time out:      1:00:36 PM
```

"authentic" contexts can play in the future of education is acknowledged, the next steps of selecting and designing situations that afford students the opportunity to acquire the important concepts of mathematics and science must begin. An ecological approach that emphasizes perception and action rather than memory and retrieval leads to a very different conceptualization of instructional design.

Changes must be made to complement the new situated cognition approach to instruction with a new ecological approach to instructional design. There is a history of changes in instructional design models that accompany changes in psychological theory. Research on programmed instruction during the 1960s showed the limitations of instructional designs based solely on behaviorist principles (Gagné, 1965; Glaser, 1963). Behaviorist techniques restricted cognitive concepts to their overt manifestations (e.g., recitation rather than understanding), and reinforcement was shown to be neither necessary nor sufficient for learning (Case & Bereiter, 1984). Gagné's (1965) hierarchical analysis approach improved the design of instructional objectives by including cognitive as well as behavioral principles, but Gagné's approach has proved limited in addressing ill-structured domains and the issues of transfer, and in accommodating the unique abilities and learning strategies of both experts and novices, and both children and adults (Resnick, 1976). Reigeluth (1983, 1987) summarized a number of competing cognitive theories of instructional design, each with its unique characteristics, strengths, and weaknesses. In all cases, the models are atomistic rather than holistic, are linear rather than integrated, separate assessment from instruction, and, according to Snow and Mandinach (1991),

> . . . move too quickly to prescription without coming to grips with the psychology of instructional variables and performance, and of diagnostic assessment for instructional adaptation. (p. 8)

A situated cognition perspective suggests that an instructional designer is faced with four basic tasks: First, the proper generator set of situations that will afford learning in the domain of interest must be selected. Second, scaffolding that allows novices and experts to perform alongside one another in the learning situation must be designed. Third, the instructional design task must include training teachers to understand and perform using the situation as well as support their role in the classroom with technology that can facilitate guiding and assessing students as they work within an instructional situation. Fourth, assessment must be integrated with instruction so that the situation provides both instructional and assessment opportunities and information. An ecological approach to instructional design must include a new approach to assessment, moving away from static assessment to situated assessment that incorporates both the affordances of the environment as well as the abilities brought to the situation by the student. In fact, it is the interaction of the two that constitutes knowledge from the situated learning perspective, and therefore it is this interaction that must be assessed and rated as intelligent or underachieving. New psychometric models can be anticipated, models that acknowledge the complexity and dynamic nature of the agent-environment interaction and draw on nonlinear models to characterize them.

An ecological approach to instructional design also suggests that new metrics for the evaluation of situations must be adopted. When instruction takes place in a complex, realistic, and "authentic" context, then measures of success of the instruction must include transfer, the meaningfulness of learning, and a capacity to anchor instruction across the curriculum. Perhaps the most important concern with situating learning in a single context (or in a few contexts) is the danger that the acquired knowledge will be tied to only those contexts in which it was learned (e.g., one student in the microanalysis reported that he liked problem solving with the Jasper eagle problem, but he was really only interested in cars—ignoring the transfer of distance/rate/time concepts across the two topics). Therefore, it is essential that learning in context be demonstrated to transfer to both closely related situations and to situations where only the most abstract or higher-level thinking skills are invariant across the situations. It is important that students learning in realistic contexts be aware of the meaning provided by the situation and access their own everyday knowledge (including beliefs, goals, and intentions) related to the context. Finally, it will be important that the situations selected afford integrated instruction, anchoring instruction across traditional subject boundaries. ☐

Michael F. Young is with the Educational Psychology Department at the University of Connecticut.

REFERENCES

Bereiter, C. (1991). Implications of connectionism for thinking about rules. *Educational Researcher, 20*(3), 10–16.

Brown, A. L., & Campione, J. C. (1990). Communities of learning and thinking or A context by any other name. In D. Kuhn (Ed.), Developmental perspectives on teaching and learning thinking skills [Special Issue]. *Contributions to Human Development, 21,* 108–126.

Brown, A. L., & Palincsar, A. S. (1988). Guided, cooperative learning and individual knowledge acquisition. In L. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser.* Hillsdale, NJ: Lawrence Erlbaum.

Brown, J. S., Collins, A., & Duguid, P. (1989, Jan–Feb). Situated cognition and the culture of learning. *Educational Researcher,* 32–42.

Bruner, J. (1986). *Actual minds, possible worlds.* Cambridge, MA: Harvard University Press.

Campione, J. C., Brown, A. L., & Connell, M.L. (1988). Metacognition: On the importance of understanding what you are doing. In R. I. Charles & E. A. Silver (Eds.), *The teaching and assessing of mathematical problem solving* (pp. 93–114). Reston, VA: National Council of Teachers of Mathematics.

Case, R. (1985). *Intellectual development: Birth to adulthood.* Orlando, FL: Academic Press.

Case, R., & Bereiter, C. (1984). From behaviorism to cognitive behaviorism to cognitive development: Steps in the evolution of instructional design. *Instructional Science, 13,* 141–158.

Clancey, W. J., & Roschelle, J. (in press). Situated cognition: How representations are created and given meaning. *Educational Psychologist.*

Chi, M. T. H., & Koeske, R. D. (1983). Network representation of a child's dinosaur knowledge. *Developmental Psychology, 19*(1), 29–39.

Cognition and Technology Group at Vanderbilt. (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher, 19*(6), 2–10.

Cognition and Technology Group at Vanderbilt. (1992). The Jasper experiment: An exploration of issues in learning and instructional design. *Educational Technology Research and Development, 40*(1), 65–80.

Collins, A. (1991, Sept.). The role of computer technology in restructuring schools. *Phi Delta Kappan,* 29–36.

Collins, A., & Brown, J. S. (1988). The computer as a tool for learning through reflection. In H. Mandl & A. Lesgold (Eds.), *Learning issues for intelligent tutoring systems.* New York: Springer.

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

Dewey, J. (1938). *Experience and education.* New York: Collier Macmillan.

diSessa, A. A. (1983). Phenomenology and the evolution of intuition. In D. Gentner & A. Stevens (Eds.), *Mental models* (pp. 15–33). Hillsdale, NJ: Lawrence Erlbaum.

diSessa, A. A. (1988). What will it mean to be "educated" in 2020? In R. S. Nickerson & P. P. Zodhiates (Eds.), *Technology in education: Looking toward 2020.* Hillsdale, NJ: Lawrence Erlbaum.

Gagné, R. M. (1965). *The conditions of learning* (1st ed.). New York: Holt, Rinehart, & Winston.

Gibson, J. J. (1986). *The ecological approach to visual perception.* Hillsdale, NJ: Lawrence Erlbaum. (Original work published 1979)

Glaser, R. (1963). Instructional technology and the measurement of learning systems. *American Psychologist, 18,* 510–522.

Greeno, J. G. (1992). Mathematic and scientific thinking in classrooms and other situations. In D. F. Halpern (Ed.), *Enhancing thinking skills in the sciences and mathematics.* Hillsdale, NJ: Lawrence Erlbaum.

Greeno, J. G., Smith, D. R., & Moore, J. L. (in press). Transfer of situated learning. To appear in D. Detterman & R. Sternberg (Eds.), *Transfer on trial.*

Kulikowich, J. M., & Young, M. F. (1991). *Complementing verbal report techniques with other modes of assessment.* Paper presented to annual meeting of Northeastern Educational Research Association, Ellenville, NY.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life.* Cambridge, MA: Cambridge University Press.

Pea, R. D. (1988, August). *Distributed intelligence in learning and reasoning processes.* Paper presented at the meeting of the Cognitive Science Society, Montreal.

Reigeluth, C. M. (Ed.). (1983). *Instructional design theories and models: An overview of their current status.* Hillsdale, NJ: Lawrence Erlbaum.

Reigeluth, C. M. (Ed.). (1987). *Instructional theories* *in action: Lessons illustrating selected theories and models.* Hillsdale, NJ: Lawrence Erlbaum.

Resnick, L. B. (1976). Task-analysis in instructional design: Some cases from mathematics. In D. Klahr (Ed.), *Cognition and instruction* (pp. 51–80). Hillsdale, NJ: Lawrence Erlbaum.

SCANS (Secretary's Commission on Achieving Necessary Skills). (1991). *What work requires of schools: A SCANS report for America 2000: Executive Summary.* Washington, DC: U.S. Dept. of Labor.

Shaw, R., Turvey, M. T., & Mace, W. (1982). Ecological psychology: The consequence of a commitment to realism. In W. B. Weimer & D. S. Palermo (Eds.), *Cognition and the symbolic processes* (Vol. 2, pp. 159–226). Hillsdale, NJ: Lawrence Erlbaum.

Shoenfeld, A. H., Smith, J. P., & Arcavi, A. (in press). Learning: The microgenetic analysis of one student's evolving understanding of a complete subject matter domain. In R. Glaser (Ed.), *Advances in instructional psychology (Vol. 4).* Hillsdale, NJ: Lawrence Erlbaum.

Simon, H. A. (1981). *Sciences of the artificial* (2nd ed.). Cambridge, MA: MIT Press.

Skinner, B. F. (1987). Whatever happened to psychology as a science of behavior? *American Psychologist, 42*(8), 780–786.

Snow, R. E., & Mandinach, E. B. (1991). *Integrating assessment and instruction: A research and development agenda* (Research Report RR-91-8). Princeton, NJ: Educational Testing Service.

Soloway, E. M. (April, 1991). *Computer support for software design activities.* Paper presented to annual meeting of the American Educational Research Association, Chicago.

Spiro, R. (1991). *Implications of cognitive complexity versus simplicity for instructional design.* Paper presented to the annual meeting of the American Educational Research Association, Chicago.

Tennyson, R. D., & Buttrey, T. (1980). Advisement and management strategies as design variables in computer-assisted instruction. *Educational Communication and Technology Journal, 28,* 169–176.

Van Haneghan, J., Barron, L., Young, M., Williams, S., Vye, N., & Bransford, J. (1992). The Jasper Series: An experiment with new ways to enhance mathematical thinking. In D. F. Halpern (Ed.), *Enhancing thinking skills in the sciences and mathematics.* Hillsdsale, NJ: Lawrence Erlbaum.

Vicente, K. J., & Harwood, K. (1990). A few implications of an ecological approach to human factors. *Human Factors Society Bulletin, 33*(11), 1–4.

Vygotsky, L. S. (1978). Internalization of higher psychological functions. In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.), *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wegner, D. M. (1987). Transactive memory: A contemporary analysis of group mind. In B. Mullen & G. R. Goethals (Eds.), *Theories of group behavior.* New York: Springer-Verlag.

Whitehead, A. N. (1929). *The aims of education and other essays.* New York: Macmillan.

Young, M., & Kulikowich, J. M. (1992a, April). *Facilitating reading comprehension through mathematical problem solving in context.* Paper presented to annual meeting of American Educational Research Association, San Francisco.

Young, M., & Kulikowich, J. M. (1992b). *Anchored instruction and anchored assessment.* Manuscript submitted for publication.

Young, M. F., & McNeese, M. D. (in press). Beyond cognition: An ecological situated cognition approach to problem solving with implications for assessment. In J. M. Flach, P. Hancock, J. Caird, & K. Vicente (Eds.), *The ecology of human-machine systems.*