The Gordon Commission
on the Future of Assessment in Education

Toward an Understanding of Assessment as a Dynamic Component of Pedagogy

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Consider the proposition that to engage in teaching one must use assessments to inquire into:

- The nature and character of the learning person, and his/her characteristic ways of knowing;
- What the learning person knows, needs to know and knows how to do;
- What learning and mediating processes are associated with effective teaching and learning for this learner;
- What is being learned by the learner and the disposition to learn it.

If such a proposition is accepted as part of the teaching enterprise, the authors submit that it requires a dynamic pedagogy- a form of teaching that integrates assessment, curriculum and instruction in the service of learning. We use the term "dynamic" to describe the process of teaching and learning in which assessment, instruction, curriculum and learning are inseparable processes in pedagogy. The constant adaptation of assessment, curriculum and instruction in response to both the potential and demonstrated learner behavior adds a labile quality to the construct. We define "pedagogy" as a form of teaching in which the actual actions taken by the teacher in these three areas are intended to promote both the process and outcomes of student learning. In order to clarify this definition of pedagogy, it is important to examine how it may be distinguished from the concept of instruction. Pedagogy constitutes a broad range of elements in curriculum, assessment and instruction that teachers orchestrate and use to promote student learning. Instruction is defined as the specific techniques and strategies (e.g. questioning strategies, giving feedback to students) that teachers use to engage students in the classroom activities to promote student learning. In our definition of pedagogy, instruction is one component of an interrelated set of curricula and assessment strategies that teachers use in the service of learning.

In this review and position paper the case is made for the functional integration of assessment, curriculum, and instruction as instrumental to learning and as the essential components of pedagogy. In the first section of the essay we propose a rationale for assessments that contribute to the improvement of student learning. In the second part of the essay we put forth the conceptualization of *Dynamic Pedagogy* of which assessment

is an essential component and is followed by a theoretical and empirical support for the various components. Using the conceptualization of assessment as a component of *Dynamic Pedagogy*, we developed a framework for organizing learning-centered assessments in the classroom. The essay ends with a discussion of the interdependency of assessment with curriculum and instruction and how this interdependency relates to the future of assessments.

Rationale for Learning-centered Assessments

One of the most often cited aims of schooling in the US is the improvement of knowledge, skills and disposition for living in a competitive global society. In recent years, educational policy has become increasingly focused on standardized assessment as an instrument to aid in achieving this aim (e.g. National Assessment of Educational Progress; state achievement tests in content areas. The results of these forms of assessment provide some information related to student learning - proficiency in basic skills and domain-specific knowledge and skills. However, because such measures are designed for the purpose of providing comparative information about students learning at a particular point in time (e.g. end-of year instruction) with respect to content standards, other measures are needed that provide credible information about how to help student learn. If, however, assessments are to inform the improvement in learning, then they cannot function independently from the curriculum. The acquisition of expected knowledge, skills, understanding, higher order thinking and problem solving indicative of learning are shaped by the opportunities afforded learners to develop these competencies within a discipline organized around interrelated concepts and principles (the curriculum). This fact suggests, then, that the content is an essential feature of a learning-centered assessment and its form may vary as well. For example an assessment used to elicit information about students' prior knowledge related to solving a problem within the mathematics domain, is different from an assessment used to check student's metacognitive skill while solving a problem.

Assessment is linked to learning through instruction in that the results of assessment function as feedback about strengths and weaknesses about the learner's performance in relation to a given task. In the example of problem solving, the results

from assessment may be used to provide assistance in the form of instructional supports and may include modeling the problem solving processes, reducing the difficulty level of the problem, using hints and cues to direct the leaner to critical features of the problem to be solved. Again, the form of what we call "assisted-assessments" may be quite varied and include open-ended questions, observations, collections of samples of student work or their self-evaluations.

Assessment as a Component of Dynamic Pedagogy

New insights about learning from research from the cognitive and learning sciences about how children learn should guide the next generation of assessments. But there are other considerations. In recent years, reform-minded educational policymakers and researchers, interested in the improvement of student learning have become increasingly focused on the curriculum and how that curriculum should be taught. For example, specialized professional associations in mathematics, science, English Language Arts and Literacy, World Languages, Social Studies, developed standards that articulate what students should know and be able to do in each discipline. Inquiry skills and conceptual understanding of core ideas in science, problem solving, communication, mathematical reasoning, and mathematical connections in mathematics, formulation of historical questions, interrogation of historical data, and employment of quantitative analysis in history are illustrative of the kinds of competencies envisioned for learners by designers of curriculum in these disciplines. How students are supported to develop these domain-specific competencies brings attention to the importance of the purpose and function of the relationship of instruction to learning. The adaptation of subject matter knowledge for pedagogical purposes (Shulman, 1987; "psychologizing" of the subject matter (Dewey, 1902/1969; and Bruner's psychology of a subject matter (Bruner, 1966), are examples of instructional approaches that have the improvement of student learning as its focus. Thus, to understand the process and product of learning requires an understanding of its relationship to curriculum and instruction. However, we argue that it is the dynamic interaction of all three: assessment-curriculum-instruction with learning as the focus in which student learning is optimized. We view the interdependency of assessment, curriculum and instruction in the service of the process and product of

learning as a special type of teaching that we call "Dynamic Pedagogy" and elaborate on its components in the section that follows.

The Dynamic Pedagogy Model

Dynamic Pedagogy is a socio-cognitive approach to teaching in which assessment, curriculum and instructional processes are united in the service of student learning as illustrated in Figure 1.

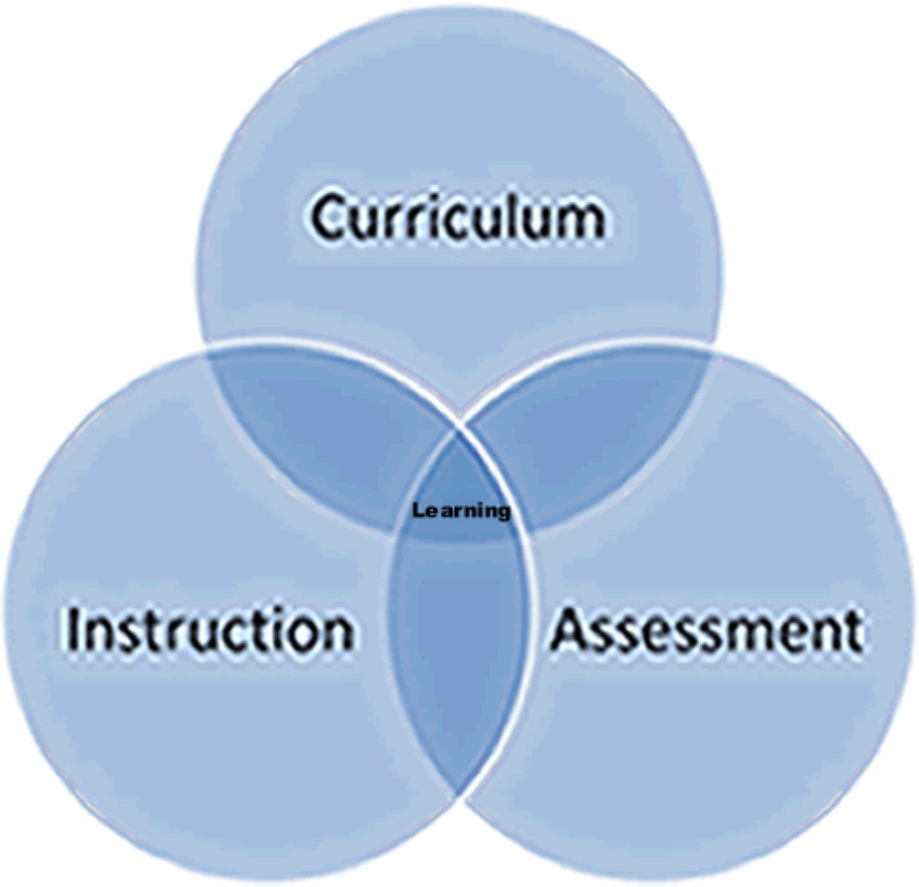

Figure1. Dynamic Pedagogy

The interlocking circles indicate the interdependence of assessment, curriculum and instruction and the jagged lines are intended to depict the dynamic interaction among

these three areas of pedagogy in response to the learning strengths and needs of the learner. A discussion of the components of the Dynamic Pedagogy (DP) model follows.

The Learning Strand of Dynamic Pedagogy

Theoretical and empirical research in cognitive and learning sciences has provided the foundational knowledge base about learning. This knowledge base offers insights about the products and processes of learning, the context and conditions of their learning, and the characteristics of the learners that influence how well they learn. These understanding become the focus of assessment as well as other areas of pedagogy that intersect with assessment. A discussion of these dimensions of learning follows:

Intellective competence is the ultimate outcome of learning

A challenge often voiced among educational policy makers today is how best to prepare students with the knowledge, skills and disposition for living in an increasingly globalized 21st century. The kinds of knowledge and skills that would be needed are those that are in the service of the development of adaptive human intellect, which the second author defined as *intellective competence* the effective orchestration of affective, cognitive, and situative mental processes directed toward what we want learners to become. To be clear, Gordon does not undervalue the importance of improving students' discipline-based knowledge and skills but he sees these academic achievements as instrumental to more purposive ends – the development of student ability and disposition to adaptively and efficiently use knowledge, technique and values in mental processes to engage and solve both common and novel problems. In short, Gordon is convinced that the end goal of learning is less about what learners are expected to know and be able to do in any academic discipline of interest but more about our expectations of what they should become- autonomous, intentional learners who are sensitive, compassionate, thinking and productively cooperative members of human communities.

All children have the potential to learn

Capacity to learn involves the enhancement of latent abilities. Several authors (Campione & Brown, 1987; Feuerstein, 1979; Lidz, 1996) suggest that some children from

culturally-diverse backgrounds, children with learning disabilities or students from impoverished environments have the capacity to learn more than the results of conventional tests of their abilities would indicate. "Learning potential," (Budoff, 1969), "developing expertise," and "latent abilities" (Sternberg and Grigrionko, 2000) are terms use to describe abilities not yet matured but which can be developed through mediated learning experiences. Vygotsky (1978) used the concept of the zone of proximal development to describe the "distance between the actual developmental level as determined by independent problem solving and the level of potential development as determine through problem solving under adult guidance or in collaboration with more capable peers" (1978, p. 86).

The importance of prior knowledge for new learning

A widely shared view about learning from a cognitive and sociocultural perspective is that new learning is shaped by prior knowledge relevant to the new knowledge to be learned (Bransford and Franks, 1971; Anderson, 1995; Flavell, Miller and Miller, 1993; Resnick & Klopfer, 1989; and Schneider, 1993). Knowledge is organized in an interrelated way and stored in memory as knowledge structures, In accounting for the role of prior knowledge structures in new learning, Gagne and Dick, (1983) suggest that knowledge structures help retention of new materials by providing a scaffold or framework for storage but may also modify the new information by making it "fit" the expectations of already existing knowledge structures.

Although prior knowledge is necessary for new learning, researchers have found that misconceptions may impede future learning (Byrnes, 1996; Halpern & Hakel, 2003; DeCorte, 2003). Misconceptions may be described as distorted knowledge that results when new information is filtered through knowledge structures that are themselves superficial, naïve, incomplete or downright incorrect.

Building on previous learning to construct new knowledge and skills

Once prior knowledge is activated relevant to the new learning, the learner uses that knowledge to construct new knowledge that includes both factual knowledge and conceptual understanding. Cognitive perspectives of development and learning suggest a

number of factors that play a critical role in these outcomes of learning: social interaction between the learner and knowledgeable adult or capable peer (Vygotsky, 1978; Wood, Bruner and Ross, 1976); the active role of the learner in using cognitive and metacognitive in making sense of the new information (Frederiksen and Collins, 1989); the use of assimilation and accommodation process in fitting factual knowledge and conceptual understanding into existing knowledge structures (Piaget, 1970); the cultural context (Cole, Gay, Glick, and Sharp, 1971); and the structure of the knowledge to be mastered (Bruner, 1960; National Research Council, 2001).

Learning-related characteristics of the Learner

The research literature suggests that there are a variety of cognitive, emotional, and cultural patterns of an individual's response to specific environmental stimuli-situations, persons or event. Different terms have been used to describe these idiosyncratic responses: affective response tendency (Thomas and Chess, 1977); cognitive style (Messick, 1976); thinking style (Sternberg, 2001); learning style (Dunn and Dunn, 1978); behavioral tendencies (Gordon, 1991). Level of energy deployment, degree of focus, persistence, intensity of effort in the effort, are some of the behavioral manifestation of these personologic characteristics of the learner that speak to the learners' level of engagement in the learning experiences in which they participate that, in turn, can affect the quantity and quality of their learning. The greater the match between the characteristics of the learner and characteristics of the task or situation the greater the likelihood that the level of engagement would be high. Conversely, a mismatch between characteristics of the learner and characteristics of the task or situation, low engagement is to be expected. One implication of this body of research is that the selection of tasks or the conditions under which tasks are made available for learners should elicit their initial interest, and sustain it until successful completion of the task.

Learning is shaped by the social context

Theoretical and empirical studies in cognitive psychology and learning sciences hold that development, learning and cognition are inextricably wedded to the context in

which they occur (Bransford, Brown, and Cocking 1999; Greeno, 1998; Greeno, Collins and Resnick, 1996; Nitsche, 1997; White and Frederiksen, 1998). Here, context is defined as the social and physical system in which the learner participates and the learning process is conceptualized as changes in participation in socially organized activity (Lave, 1988; Lave and Wenger, 1991). Several studies have demonstrated how the acquisition, understanding, and application of domain-specific concepts and principles grew out of individuals' sociocultural experiences (Gutierrez, Baquedano-Lopez, and Alverez, 1999; Lee, 2007; Ma, 1999; Moses, Kamii, Swap, & Howard, 1989; Saxe, 1988; Valdes, 2001).

Consolidation and automaticity are key processes in learning

After learners have acquired factual knowledge and conceptual understanding, it is important that the new learning endures over a long time and are stored well in long-term memory. To ensure permanence of the new learning, learners need to consolidate the acquisition of factual knowledge and deep understanding of concepts, as well as to be able to perform complex tasks with automaticity. Both concepts in research suggest that consolidation of learning through practice spaced over time increases retention of knowledge (Dempster, 1989; Krug, Davis and Glover, 1990); and makes easy retrieval from memory later (Anderson, 1983). Automaticity is also important for learning if the knowledge or skills to be learned requires speed and limited mental effort. Like consolidation, automaticity can be achieved through practice (Bloom, 1985).

Meaningful learning involves the transfer of learning to other contexts

The transfer of knowledge and understanding achieved in one context to another context is evidence that meaningful new learning has occurred. Although the research is not conclusive there appears to be some promising findings about the kinds of experiences conducive to transfer: opportunities to practice new concept or skill in different situations (Cox, 1997; Reimann & Schult, 1996); opportunities to practice retrieval of previously learned materials from long-term memory (Dempster, 1989; Dempster and Perkins, 1993; Glover, 1989); opportunities to practice varieties of applications while learning (Topping, Samuels & Paul, 2007); initial learning must be

embedded in a knowledge-rich context (Bransford, Brown and Cocking, 1999); opportunities for deep understanding of concepts and skills during initial learning of concepts and skills (Bransford and Stein, 1993).

Adept learners are both cognitive and metacognitively competent

Learning cannot occur without the use of some type of thinking or cognitive processes in any given task in or out of school. But skill and disposition to use thinking processes effectively not only enhances learning in various academic subject areas but help students achieve success in their post high school education and the world of work. Various scholars have developed taxonomies of thinking skills over the years. For example, Bloom et al (1964) developed a taxonomy of cognitive processes to describe a range from low-level processes (identifying, comparing, labeling to higher-level cognitive processes analyzing and evaluating and synthesizing) that have been used in many academic subjects and across grade levels. More recently, Beyer (1988) developed a classification of thinking processes consisting of three levels of complexity: Level I problem solving, decision making and conceptualizing; Level II critical thinking skills and Level III information processing skills. Like Bloom's taxonomy, these thinking processes have been infused in discipline-specific curricula in K-12 programs. Sternberg's (1997) creative, analytical and practical thinking processes is yet another example of a cluster of thinking processes underlying successful intelligence. In a series of instructional studies Sternberg and his colleagues found that when students were taught in a manner that best fit how they think, they outperformed students who were placed in instructional conditions that did not match their pattern of abilities (Grigorenko, Jarvin, & Sternberg, 2002; Sternberg, Grigorenko, Ferrari, & Clinkenbeard, 1999; Sternberg, Torff, and Grigorenko, 1998). These studies are important given the recent calls among educational policy makers for evidence of impact of teaching on student learning and academic achievement.

There is, of course more too skilled thinking than the expert use of cognitive processes in learning in any given content area. Attention must also be given to the enhancement of students' awareness and use of executive thinking processes, sometimes describe as metacognition (Flavell, 1979); metacomponents (Sternberg, 1986; higher-

order thinking, Armour-Thomas, Bruno, and Allen, 1992). A well-established finding from cognitive science research is that competent learners are metacognitively competent, (i.e. they are aware of and are able to control their own learning using a variety of self-planning, monitoring and evaluation processes). Some researchers make a distinction between metacognitive knowledge and self-regulatory skills although it appears that both are important for learning in a variety of domains (Artzt and Armour-Thomas, 1992; Hartman, 2001; Palinscar & Brown, 1984; Schoenfeld, 1987).

The Assessment Strand of Dynamic Pedagogy

The assessment strand of *Dynamic Pedagogy* functions within the actual implementation of a lesson and has two components. The first one is a type of *"on-line" probe* that is used (1) to probe their prior knowledge, skills, and readiness for new learning, (2) to check their emerging understanding of new concepts and procedures as well as misconceptions; (3) to check whether they have acquired the new knowledge and skills; (4) to check how well they are able to demonstrate their knowledge and skills with automaticity; (5) to check how well they have consolidated their new learning; (6) how well they are able to transfer it to other contexts; (7) to check the mental processes engaged during learning; and (8) to check disposition and motivational level while engaged in tasks. The term has a similar meaning to Campione's (1989) "on-line diagnosis" or Slavin's (2001) "learning probes" or Gickling and Havertape's (1981) "curriculum-embedded assessments". On-line probes provide iterative dynamic feedback that is used to inform adaptive instruction. Some on-line probes may take the form of questioning and may serve many purposes throughout the lesson. For example, questions may be used to elicit clarification on students' thinking, encourage elaboration of their ideas or to help them make a mental bridge to another idea. Other probes may ask students to demonstrate their understanding in written form, verbally, pictorially, or kinesthetically. Assessment in this context is formative and dynamic in nature since its results are used as feedback to inform subsequent decisions about curriculum and instruction.

The second component of assessment consists of *Metacognitive Probes*. These probes describe the variety of ways the teacher assesses the extent to which students are

aware of effective learning strategies and know when and how they are to be applied. In describing this form of self-assessment, some researchers use the term higher order thinking (Armour-Thomas, 1992; Frederiksen & Collins, 1989); metacognition (Flavell, 1979); regulation of cognition (Schraw, 2001); metacomponents (Sternberg, 1985; talk-aloud problem solving (Whimby & Lochhead, 1982) and self-regulated learning (Schunk and Zimmerman, 1997). Many studies have found that highly competent students are aware of and use these higher-level cognitions in their learning (Hartman, 2001; Paris & Newman, 1990; Winne, 1995, Zimmerman and Risenberg, 1997; Sternberg, 2001) Examples of these probes include teacher questions such as: "What is this problem asking you to do? "Why did you select this strategy?" "How do you know your answer is correct?" "How do you know you are on the right track?"

The assessment strand is related to the curriculum strand of DP in at least two ways. The first is the content of the assessment procedure itself. For example, if the assessment calls for students to show their understanding of equivalence fractions, the content of the assessment may include a word problem with information pertaining to equivalence – a topic in the grades k-4 standards-based curriculum. The second way assessment is related to curriculum is if the feedback from assessment results is used to make modifications in the teacher's subsequent curricula decisions. In the example of the assessment of equivalence, the results may show that some children may have difficulty in figuring out that two fractions are the same even though the numerators and denominators are different. The teacher may decide to use such feedback to design a task that requires students to revisit part-whole relationships, a precursor to understanding equivalent fractions. A fuller discussion of the curriculum strand follows.

The Curriculum Strand of Dynamic Pedagogy

The curriculum strand of Dynamic *Pedagogy* consists of the full range of materials (e.g. text, media, and workbooks) that embody the concepts, principles and procedures of a discipline. Most scholars acknowledge that the term curriculum encompasses a body of content knowledge to be learned. But curriculum involves more than content. A more expansive notion of the concept of curriculum implies that the structure of that body of knowledge is embedded in curricula form, i.e., and the form of

how knowledge is organized and presented within a curriculum. How that knowledge is learned (i.e. acquired, produced, or constructed) depends on what content is selected for learning; how it is communicated to the learner- decisions by the teacher that involves his/her use of instructional and assessment strategies. This notion of curriculum also implies the thinking or cognitive processes required for acquiring, producing, and ultimately transferring that body of knowledge are embedded in the curriculum. It also implies attention to characteristics or attributes of tasks that instantiate the curriculum: Do tasks have attributes that arouse and sustain their motivation to learn and to use their minds well. For example, do tasks allow students to make connections to their prior knowledge and skills and to build new knowledge? Are tasks open to multiple representations and multiple ways of knowing the content? Are tasks relevant to students' personal interests and do they arouse and sustain their motivation in them until successful completion? Do tasks engage students in metacognitive and cognitive thinking about a discipline's concepts and its underlying principles? We have selected Artzt and Armour-Thomas (2002) recommendations to teachers about designing tasks that are relevant for helping students to actively engage in meaningful problem solving: (1) set tasks at the appropriate level of difficulty; (2) sequence tasks in ways that students can progress in their cumulative understanding of a particular content area; (3) select tasks with attributes that initially attract, sustain their attention and emotional investment over time; (4) design tasks that allow students to make connections between concepts and principles earned in the past and those that they will learn in the future; (5) select appropriate modalities for representing tasks.

The curriculum strand was also informed by Sternberg's theory of intelligence (1985) that posits that, along with memory, there are three kinds of abilities, analytic, creative and practical that draws upon a common set of information processing components and metacomponents, performance components and knowledge-acquisition components. What distinguish these abilities are the experiences and contexts to which these information-processing components are applied. Thus, analytical ability drawn upon information processing components for relatively familiar tasks that require the individual to analyze, judge, evaluate, compare and contrast; information processing components for creative ability (e.g. ability to discover, invent, create, explore) are

applied to relatively novel tasks or familiar tasks conceptualized in a novel way. And, finally, information-processing components for practical ability (e.g. ability to put into practice, apply, use and implement) are applied to either familiar or novel tasks in everyday contexts or settings. We argue that if students are exposed to tasks that require them to think about concepts and procedures in these multiple ways, they are likely to learn more deeply about the content of a discipline. But even more importantly, we think that consistent and prolonged use of these kinds of cognitive and metacognitive processes for solving common and novel problems are crucial for the development of intellective competence.

The curriculum strand is related to the assessment strand in that, choice of level and types of probes depend, in part, on the level and complexity of the task and its attendant cognitive and motivational demands on the learner. The example of equivalent fractions was used earlier to illustrate the relationship between the assessment strand and curriculum regarding the cognitive demands of the leaner. The example may also be used to illustrate the interdependency of curriculum and assessment when the motivation of the learner is considered. The assessment of equivalence fraction using the format of a word problem, may have less motivational appeal for some children from culturally diverse background whose ways of demonstrating what they know and can do are at odds with the cultural norms of teacher-made assessment. Or, other children may have conceptual understanding of equivalence but may not be motivated to demonstrate their competence because of limitations in their proficiency with the language of assessment. Using other types of assessment to measure the same concept (e.g. asking students to show their understanding of equivalent fractions using open-ended tasks or using a different symbol system other than words to represent the problem) may yield more reliable and valid results from these types of curriculum-embedded assessments.

Another way that the curriculum strand overlaps with the assessment strand is in the design of tasks and assessments at different phases of the learning process. In helping learners to construct their own knowledge and skills related to a given domain, the teacher may design tasks different from those where the objective is to help them transfer knowledge and skills to another domain or context. To assess learning in each phase of

the learning process would necessitate that the forms of assessments be compatible with the demands of the task.

The Instructional strand of Dynamic Pedagogy

The instruction strand of *Dynamic Pedagogy* consists of a variety of strategies to help students learn and, for the most part, is based on cognitive science research. One set of strategies deal with the importance of cognitive supports to help students learn with understanding and include providing prompts, modeling, use of prompts, thinking aloud while demonstrating how to approach a task, guided practice, and supervised independent practice (Jeroen, Van Merreinboer and Kirschner, 2007; Mayer, 2009). Another set of strategies have to do with cultivating a disposition to learn well or what some authors call "habits of mind" (Brown and Palinscar, 1989; Costa and Kallick, 2008; Resnick, (2001) or "a habit of inquiry" (Newman and Associates, 1996; Wiggins, 1993). Although strategies vary, depending on the scholar's perspective of what constitutes "habits of mind, or " a habit of inquiry", they generally focus on teaching critical thinking skills (Ennis, 2001), creative problem solving (Beyer, 1997; Frederiksen, 1984); stand alone thinking skills (Feuerstein, 1980; Sternberg, Kufman and Grigorenko, 2008) or infusion of thinking skills in the curriculum (Perkins and Salomon, 1987; Sternberg, 1998; Sternberg, Torff, and Grigorenko, 1998).

The instructional strand is related to the *assessment* strand in that results of assessment may reveal learner strengths and weaknesses that could be addressed in two ways. First, the teacher may give feedback to the learner not only in areas where he or she experienced difficulties but also feedback on how to improve one's learning. Secondly, based on assessment results, the teacher may use different instructional strategies when re-teaching the concept or alter the pace of instruction. The example of equivalent fractions used earlier to illustrate the relationship between the assessment strand and curriculum may be used again to illustrate the overlap of assessment with instruction. For students who showed incomplete grasp of the concept of equivalent fractions, the teacher may decide to engage in a one-on-one instruction using a judicious mixture of scaffolding and guided practice strategies. In addition, the teacher may use the results from assessment to provide explicit criteria for assessing their own strengths and

weakness in solving the problem of equivalent fractions. The purpose of the latter strategies is to help students develop the disposition for approaching similar problems in the future.

A framework for Examining Assessment within the Dynamic Pedagogy Mode

Assessment decisions alone cannot inform the improvement of learning since they are inextricably wedded to other components of pedagogy, namely curriculum and instruction. How then might assessment for learning be conceptualized given its indivisibility with curriculum and instruction? We think a multi-dimensional framework is necessary that conceptualizes the different types of decision making about assessments and its dynamic interdependency with curriculum and instruction and its relationship to learning. Based on our review of research on student learning, assessments, curriculum and instruction as discussed in the previous section, we have identified four dimensions of assessment that overlaps with curriculum and instruction with student learning at the nexus of all three components of Dynamic Pedagogy. Within each of the four dimensions are indicators of the specific actions and decisions pertaining to assessment as a dynamic component of pedagogy.

Learning goals and objectives

Learning goals and objectives describe the anticipated outcomes for students at the end of a lesson, curriculum unit or course. There at least four attributes of learning goals and objectives: specification of what the is important for the learner to know and be able to do; specification of the thinking embedded in what is important for the learner to know and be able to do; the congruence of the form and content of assessment with learning goals and objectives; and accuracy and fairness of learning goals and objectives.

- Do learning goals and objectives indicate the domain-specific knowledge, skills and dispositions expected of students?
- Do learning goals and objectives indicate both the cognitive and metacognitive thinking expectations for students for the expected domain-specific knowledge, skills and disposition?

- Is the content of assessments congruent with the learning goals and objectives?
- Is the form/format of assessments congruent with the learning goals and objectives?
- Are assessments likely to yield fair and accurate results about the achievement of learning goals and objectives?

Phases of Learning

Phases of learning describe transition points in the learning cycles when learners use different thinking processes to engage the task/s at hand. The phases are sequential in the sense that the learner has to accomplish certain tasks before proceeding to others. However, the thinking in each phase is both sequential yet recursive. For example, the thinking the learner engages in while activating prior knowledge from memory is different from the thinking he/she engages in when constructing new knowledge. Yet, the thinking processes recur when, in connecting a new concept to something familiar, the learner may have to go back into memory to verify it. We contend that learning occurs in three phases: readiness for new learning; building new learning on previous learning; and consolidating and transfer of new learning.

Preparation for learning

- Do assessments assess the quality of prior knowledge relevant for new learning?
- Do assessments assess for misconceptions?
- Do assessments assess for students' awareness and use of cognitive and metacognitive thinking process?
- Is the form/format of assessments compatible with the function of activities in this phase of learning?
- Is content of assessments compatible with the function of activities in this phase of learning?
- Do assessments take into account learner characteristics?
- Do assessments take into account the context of learning?
- Do assessment results provide feedback to the learner?
- Do assessment results provide feedback to the teacher?

Building on previous learning

- Do assessments assess for the quality of knowledge construction and sense making?
- Do assessments assess for the quality of emerging understanding of new concepts, procedures?
- Do assessments assess for students' awareness and use of cognitive and metacognitive thinking process?
- Is the form/format of assessments compatible the function of activities in this phase of learning?
- Is the content of assessments compatible with the function of activities in this phase of learning?
- Do assessments take into account learner characteristics?
- Do assessments take into account the context of learning?
- Do assessment results provide feedback to the learner?
- Do assessment results provide feedback to the teacher?

Consolidating and transfer of new learning

- Do assessments assess for the quality of consolidation of new learning?
- Do assessments assess for the quality of automaticity of new learning?
- Do assessments assess for transfer of new learning to other contexts?
- Is the form/format of assessments compatible with the function of activities in this phase of learning?
- Is the content of assessments compatible with the function of activities in this phase of learning?
- Do assessments check for students' awareness and use of lower order and higher –order thinking process?
- Do assessments take into account learner characteristics?
- Do assessments take into account the context of learning?
- Do assessment results provide feedback to the learner?

- Do assessment results provide feedback to the teacher?

Future directions of assessment

In our vision of the future of assessment, the improvement of learning is its central purpose. It functions in dynamic interaction with curriculum and instruction which themselves have the improvement of learning as its central purpose. Decisions about the form and content of assessment are informed by a socio-cultural perspective of learning, curriculum and instruction and its results are used by both the teacher and the learner to guide future teaching and learning. We put forth a multi-dimensional framework for organizing views of assessment as part of the teaching-learning process. We now suggest four additional issues that would need to be considered for this conceptualization of assessment to truly make a difference in the lives of learners and teachers in the future: (1) Make learning-centered assessments count in the evaluation of learning and teaching, (2) Use computer technologies to develop learning-centered assessments, (3) Ensure the validity and fairness of learning-centered assessments, and (4) Prepare teachers for using learning-centered assessments.

Make learning-centered assessments count in the evaluation of learning and teaching

A growing trend in recent years is the use of standardized achievement tests results to hold teachers, schools and districts accountable for what students learn in a given context. Typically, tests that meet rigorous psychometric criteria of reliability and validity are used to document achievement performance of students after a year of schooling. Some educational policy makers use the results from such assessments to inform instruction in the classroom. But, as we have argued earlier, test scores do not tell the complete story on student learning and should be complemented by learning-centered assessments that are used in the classroom as a part of the learning process and therefore more closely tied to curriculum and instruction. Such assessments are oftentimes described as “formative” since its purpose is two-fold: to inform the learner and the teacher about aspects of learning and teaching that are going well and aspects that need improvement. To ensure complementarity between standardized tests and learning-centered assessments, both measures would need to reflect the same subject-matter

content and the same learning goals and objectives. A common form of assessment, though used for different purposes, would be a necessary requirement as well.

Use computer technologies to develop learning-centered assessments

The primary purpose of learning-centered assessments is to provide feedback to the learner and the teacher. The learner uses the feedback to improve his/her learning and the teacher uses the feedback to make modifications in his/her subsequent curricula or instructional decisions. Management of the data can be quite labor intensive and require an enormous amount of time of the classroom teacher. However, in recent years, the convergence of digitalized technologies and cognitive science have led to promising technology-based assessments that could significantly improve the efficiency of learning and teaching. For example, computer-based assessments such as the Problem Solving in Technology-Rich Environments (TRE) assess inquiry skills, provide opportunities to monitor one's efforts and organize and report results. Moreover, the TRE approach has design features for assessing different levels of skill, representing problems in different modalities, opportunities for using different approaches to solving problems and verifying multiple solutions. Other examples of technology-enabled assessments include simulated games in physics (e.g. *Supercharged*) and history (e.g. *Civilization 111*) that place students in roles as scientists, investigators, doctors, giving them opportunities for independent thinking and problem solving in real life environments. Data generated from these simulations produces multiple data about students' actions and responses that may be used to guide learning and instruction. Because assessments are integrally related to curriculum and instruction, the benefits of technology-enhanced assessment would require a coordinated effort with many stakeholders among a community of stakeholders including educational policy makers, specialists in areas of curriculum, instruction, measurement and software design.

Ensure the validity and fairness of learning-centered assessments

Learning-centered assessments must meet the validity and fairness criteria if they are to provide meaningful accurate and meaningful information for further learning and teaching. For the validity issue, this would mean using multiple measures to assess

learning at any point across the learning continuum, verifying that the form and formats of assessments adequately represent the curriculum domain and that they are compatible with the process learning goals and objectives of the lesson, unit or course. With regards to the fairness criterion, decisions about learning- centered assessments must address the multiple diversities that learners bring to the learning situation (e.g. differential response tendencies, limited language proficiency, and special needs).

Changes in the preparation of teachers

To plan and implement assessment as a dynamic component of pedagogy would require teacher to have an understanding of how children and adolescents develop and learn from a social constructive perspective; standards-based curriculum instruction; the dynamic interdependence of curriculum, instruction and assessment and its relationship to student learning; assessment as feedback to inform student growth in learning and improvement in curricula and instructional decision making. But understanding of these issues is not enough. Teachers would need to have the skill in transforming their understanding about the conception of assessment as a dynamic component of pedagogy into a methodology that can be implemented in the classroom. But knowing how to do so may not necessarily mean that teachers would do so since some teachers may have beliefs that are not compatible with the conception of assessment proposed in this paper. If these ideas about assessment are to become part of teachers' daily practice, then changes would need to occur in teacher preparation programs as well as in programs for the continuing professional development of practicing teachers. Today, many teacher education programs, offer coursework in child and adolescent development and learning separate from coursework in curriculum, instruction and assessment. These learning experiences would need to be modified so that teacher candidates have an understanding of the interdependency of assessment, curriculum and instruction and its linkage to a knowledge base on how children develop and learn. Teacher candidates would also need to be provided with opportunities for reflecting on their beliefs about assessment and learning with a view toward an acceptance that they can make a difference in children's learning and their own teaching through changes in their assessment practices.

Conclusion

In this review and position paper the case is made for the functional integration of assessment, curriculum, and instruction as instrumental to learning and as the essential components of pedagogy. The argument is advanced that assessment is ongoing and that, curriculum and instruction should be considered as being pedagogically symbiotic and instrumental to learning. In addition, we assert as a priority in pedagogically relevant measurement that assessment inform and improve both the processes and outcomes of teaching and learning transactions. We began with the learning strand of Dynamic Pedagogy using a cognitive and socio-cultural perspective of learning. A number of propositions about learning were put forth about how students learn and the conditions and context conducive to their learning well. This was followed by a description of the assessment, curriculum and instruction strands of Dynamic Pedagogy showing the interdependency among them. On the basis of the conceptualization of assessment as a dynamic component of pedagogy, we developed a multi-dimensional framework for organizing the variety of decisions to inform learning-centered assessment practices in the classroom. We end with a discussion of the implications of this conceptualization of assessment for the future of assessment.

References

Anderson, J. R. (1983) *The architecture of cognition*. Cambridge, MA: Harvard University Press.

Anderson, J. R. (1995). *Learning and Memory*. New York: Wiley

Armour-Thomas, E., Bruno, K., Allen, B. (1992). Toward an understanding of higher–order thinking among minority students. *Psychology in the Schools*, vol. 29, pp. 2733-280

Artzt, A. F. & Armour-Thomas, E. (1992). Development of a cognitive-metacognitive framework for protocol analysis of mathematical problem solving in small groups. *Cognition and Instruction, 9,* 137-175.

Artzt, A. F., & Armour-Thomas, E. (2001). *Becoming a reflective mathematics teacher: A guide for observations and self-assessment*. Mahwah, NJ: Lawrence Erlbaum Associates.

Beyer, B. K. (1997). *Improving student thinking. A comprehensive approach*. Boston: Allyn & Bacon.

Bloom, B. (1985). *Developing Talent in Young People*: Ballantine Books.

Bloom, B. et al. (eds) (1964) The Taxonomy of Educational Objectives. Vol. 1 The Cognitive Domain, London: Longmans Green.

Bransford. J. D. & Franks, J.J. (1971). The abstraction of linguistic codes. *Cognitive Psychology, 2,* 331-
350.

Bransford, J. D, & Stein, B. S. (1993). *The IDEAL problem solver* (2nd Ed.). New York, NY:
Freeman.

Brandsford, J. D., Brown, A. L., & Cocking, R. R. (Eds.) (1999). *How people learn: Brain, mind, experience and school.* Washington, DC: National Academy Press.

Brown, A. L. & Palinscar, A. S. (1989). Guided cooperative learning and individualized knowledge acquisition. In. L.B. Resnick (Ed.), *Knowing, learning and instruction: Essays in honor of Robert Glaser* (pp. 393-451). Hillsdale, NJ: Erlbaum Associates.

Bruner, J. (1960). The process of education. Cambridge, MA: Harvard University Press.

Bruner, J. (1966). *Toward a theory of instruction*. Cambridge: Belknap Press of Harvard University.

Budoff, M. (1969). Learning potential: A supplementary procedure for assessing the ability to reason. Seminary. *Psychiatry, 1,* 278-290.

Byrnes, J. P. (1996). *Cognitive development and learning in instructional context*. Boston, MA: Allyn & Bacon.

Campione, J. C. (1989). Assisted assessment: A taxonomy of approaches and an outline of strengths and weaknesses. *Journal of Learning Disabilities, 22 (3)*, 151-165.

Campione, J.C. & Brown, A.L. (1987). Linking dynamic assessment with school achievement. In C. S. Lidz (Ed.), *Dynamic assessment: An interactional approach to evaluating learning potential* (pp. 82 –115). New York, NY: Guilford Press.

Cole, M., Gay, J., Glick, J., & Sharp, D. W. (1971). *The cultural context of learning and thinking*. New York: Basic Books.

Costa, A. L. & Kallick, B. (2008). *Learning and leading with habits of mind*. Alexandria, VA: Association for Supervision and Curriculum.

Cox, B. D. (1997). The rediscovery of the active learner in adaptive contexts: A developmental-historical analysis of transfer of training. *Educational Psychologist, 32*, 41-55.

DeCorte, E. (2003). Transfer as the productive use of acquired knowledge, skills, and motivations. *Current Directions in Psychological Science, 12(4)*, 142-146.

Dempster, F. N. (1989). Spacing effects and their implications for theory and practice. *Education Psychology Review, 1*, 309-330.

Dempster, F. N. & Perkins, P. G. (1993). Revitalizing classroom assessment: Using tests to promote learning. *Journal of Instructional Psychology, 20*, 197-203.

Dewey, J. (1902). *The child and the curriculum*. Chicago: Chicago University Press.

Ennis, R. H. (2001). Goals for a critical thinking curriculum. In. A. L. Costa (Ed.), *Developing minds*. Alexandria, VA: Association for Supervision and Curriculum Development.

Feuerstein, R., Rand, Y., Hoffman, M.B. (1979) *The dynamic assessment of retarded performers: The learning potential assessment devise theory. Instruments and techniques*. Baltimore, MD: University Park Press.

Feuerstein, R., Rand, Y., Hoffman, M.B., & Miller, R. (1980). *Instrumental enrichment*. Baltimore: University Park Press.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new era of cognitive-developmental inquiry. *American Psychologist, 34*, 906-911.

Flavell, J. R., Miller, P. H. & Miller, S. A. (1993). *Cognitive Development (3rd.) edition*. Upper Saddle Road, NJ: Prentice Hall.

Frederiksen, J.R. & Collins, A. (1989). A systems approach to educational testing. *Educational Researcher, 18,* 27-32.

Frederikson, N. (1984). Implications of cognitive theory for instruction n problem solving. *Review of Educational Research 54, 3,* pp. 363-407.

Gagne, E, & Dick,W.(1983). Instructional Psychology. In M. Rosenzweig and L. Porter (Eds.), *Annual Review of Psychology*. Palo Alto, CA: Annual Reviews.

Gickling, E. & Havertape, J. (1981). *Curriculum-based assessment (CBA)*. Minneapolis: National School Psychology In-service training Network.

Glover, J. A. (1989). The " testing" phenomenon: Not gone but nearly forgotten. *Journal of Educational Psychology,* 81392-399.

Gordon, E.W. (1991). Human diversity and pluralism. *Educational Psychologist, 26*, 99-108.

Gordon, E. W. (1998). *Toward a definition of pedagogy*. Working paper prepared for the National Research Council's Committee on Early Childhood Pedagogy.

Gordon, E. W. (2001). Affirmative development of academic abilities. *Pedagogical Inquiry and Praxis, No. 2.* Institute for Urban and Minority Education, Teachers College, Columbia University.

Gordon, E. W. (2002) (Personal communication).

Greeno, J. G. (1998). The situativity of knowing, learning, and research. *American Psychologist, 53(1),* 5-26.

Greeno, J. G., Collins, A. M., & Resnick, L. R. (1996). Cognition and learning. In D. C. Berliner & R.C. Calfe (Eds.), *Handbook of educational psychology* (pp. 14-46). New York: Macmillan.

Grigorenko, E. L., Jarvin, L. & Sternberg, R. J. (2002). School-based tests of the triarchic theory of intelligence: Three settings, three samples, three syllabi. *Contemporary Educational Psychology, 27*, 167-208.

Gutierrez, K., Baquedano-Lopez, P., & Alverez, H. (1999). A cultural-historical approach to collaboration: Building a culture of collaboration through hybrid language practices. *Theory into practice. 38*, 87-93.

Halpern, D. F. & Hakel, M. D. (2003). Applying the science of learning to the university and beyond. Teaching for long-term retention and transfer. *Change, 35 (4)*, 37-41.

Hartman, H. J. (2001). Developing Students' Metacognitive Knowledge and Skill. Metacognitive. In H. J. Hartman (Ed.), *Metacognition in learning and instruction: Theory, research and practice* (pp.33-68). Boston, MA: Kluwer Academic Publishers.

Jeroen, J., van Merrienboer, G., Kirschner, P.A. (2007). *Ten steps to complex learning*. Mahwah, NJ: Lawrence Erlbaum Associates.

Krug, D., Davis, T. B., & Glover, J. A. (1990). Massed versus distributed reading: A case of forgetting helping recall? *Journal of Educational Psychology, 82*, 366-371.

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

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Lee, C. A, (2007). *Culture, literacy and learning: Taking bloom in the midst of the whirlwind*. New York: Teachers College Press.

Lidz, C.S. (1995). Dynamic assessment and the legacy of L.S. Vygotsky. *School Psychology International, 16*, 143-153.

Ma, L. (1999). *Knowing and teaching elementary mathematics*. Mahwah, NJ: Lawrence Erlbaum.

Mayer, R. (2009). Constructivism as a theory of learning versus constructivism as a prescription for instruction. In S. Tobias, T. M. Duffy, (Eds.), *Constructivist instruction: Success or failure?* (pp. 184- 200). New York: Taylor and Francis.

Messick, S. (1976). Personalities consistencies in cognition and creativity. In S. Messick (Ed.), *Individuality in learning* (pp. 4-22). San Francisco: Jossey-Bass.

Moses, R.P., Kamii, M., Swap, S. M., & Howard, J. (1989). The Algebra Project: Organizing in the spirit of Ella. *Harvard Educational Review, 59*, 423-443.

National Research Council. (2001). Adding it up: Helping children to learn mathematics. In J. Kilpatrick, J. Swafford, and B. Feindell (Eds.), *Mathematics Learning Study Committee*. Washington, DC: National Academy Press.

Newman, F.M. & Associates. (1996). *Authentic achievement: Restructuring schools for intellectual quality.* San Francisco: Jossey –Bass.

Nitsche, K. E. (1997). Structuring decontextualized forms of knowledge. Unpublished doctoral dissertation, Vanderbilt University.

Palinscar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1 (2)*, 117-175.

Paris, S. G., & Newman, R. S. (1990). Developmental aspects of self-regulated learning. *Educational Psychologist, 25*, 87-102.

Perkins, D.N. & Salomon, G. (1987). Transfer and teaching thinking. In D. N. Perkins, J. Lochhead, & J. Bishop (Eds.), *The second international conference*. Hillsdale, NJ: Lawrence Erlbaum.

Piaget, J. (1970). Piaget's theory. In. P. H. Mussen (Ed.), *Carmichael's manual of psychology*. New York: Wiley.

Reinmann, P., & Schult, T. J. (1996). Turning examples into cases: Acquiring knowledge structures for analogical problem solving. Educational Psychologist, 31(2), 123-132.

Resnick, L. B. (2001). Making America smarter: The real goal of school reform. In. A. L. Costa (Ed.), *Developing minds*. Alexandria, VA: Association for Supervision and Curriculum Development.

Resnick, L.B. & Klopfer, L.E. (1989). Toward the thinking curriculum: An overview. In L.B. Resnick & L.E. Klopfer (Eds.), *Toward the curriculum: Current cognitive research*. (pp. 1-18). Alexandria. VA: Association for Supervision and Curriculum Development.

Saxe, G.B. (1988). Candy Selling and Math Learning. *Educational Researcher, 17 (6),* 14-21.

Schneider, W. (1993). Domain-specific knowledge and memory performance in children. *Educational Psychology Review, 5,* 257-273.

Schoenfeld, A. H. (1987). What's all the fuss about metacognition? In A.H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 189-215). Hillsdale, NJ: Lawrence Erlbaum Associates.

Schraw, G. (2001). Promoting general metacognitive awareness. In H. J. Hartman (Ed.), *Metacognition in learning and instruction: Theory, research and practice* (pp. 3–16). London: Kluwer.

Schunk, D. H. & Zimmerman, B. J. (1997). Social origins of self-regulatory competence. *Educational Psychologist*, 32, 195-208.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*, 4-14.

Slavin, R. E. (2001). *Educational Psychology: Theory and practice*. New York: Allyn & Bacon.

Sternberg, R. J. (1977). *Intelligence, information processing, and analogical reasoning: The componential analysis of human abilities*. Hillsdale, NJ: Erlbaum.

Sternberg, R. J. (1985). *Beyond IQ: A triarchic theory of human intelligence*. Cambridge, MA: Cambridge University Press.

Sternberg, R. J. (2001). Metacognition, abilities and developing expertise. In H. J. Hartman (Ed.), *Metacognition in learning and instruction: Theory, research and practice* (pp. 247-260). Boston, MA: Kluwer Academic Publishers.

Sternberg, R. J. Torff, B., & Grigorenko, E. L. (1998). Teaching for successful intelligence raises school achievement. *Phi Delta Kappan, 79*, 667-669.

Sternberg, R. J. & Grigorenko, E. L. (2000). *Dynamic Testing: The nature and measurement of learning potential*. MA: Cambridge University Press.

Sternberg, R. J. Grigorenko, E. L. Ferrari, M., & Clinkenbeard, P. (1999). A triarchic analysis of an aptitude-treatment interaction. *European Journal of Psychological Assessment, 15 (1)*, 1-11.

Sternberg, RJ., Kaufman, J., & Grigorenko, E. L. (2008). *Applied Intelligence*. New York: Cambridge University Press.

Thomas, A., & Chess, S. (1977). *Temperament and development*. New York: Brunner/Mazel.

Topping, K. Samuels, J., & Paul, T. (2007). Does practice make perfect? Independent reading quantity quality, and student achievement. *Learning and Instruction, 17 (3),* 253-264.

Valdes, G. (2001). *Learning and not learning English: Latino students in American schools*. New York: Teachers College Press.

Vygotsky, L. S (1978). *Mind in society*. M. Cole V. John –Steiner, S. Scribner, & E. Souberman (Eds.), Cambridge, MA: Harvard University Press.

Whimby, A., & Lochhead, J. (1982). *Problem solving and comprehension*. Hillsdale, NJ:

Lawrence Erlbaum Associates.

White, B.Y. & Frederiksen, J.R. (1998). Inquiry, modeling and metacognition: Making science accessible to all students. *Cognition and Instruction, 16 (1)*, 3-118.

Wiggins, G (1993). Assessment: Authenticity, context and validity. *Phi Delta Kappan, 74,* 200-214.

Wilson, S. M., Shulman, L. S., & Richert, A. (1987). 150 different ways of knowing: Representations of knowledge in teaching. In J. Calderhead (Ed.), *Exploring teachers' thinking* (pp. 104-124). Sussex, England: Holt, Rinehart and Winston.

Winne, P.H. (1995). Inherent details in self-regulated learning. *Educational Psychologist, 30*, 173-187.

Wood, D., Bruner, J.S. & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17,* 89-100.

Zimmerman, B.J., & Risemberg, R. (1997). Self-regulatory dimensions of academic learning and motivation. In G. D. Phye (Ed.), *Handbook of academic learning: Construction knowledge*. San Diego: Academic Press.