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Research on Learning and Instruction: Implications for Curriculum, Instruction, and Assessment

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Abstract

There is considerable rhetoric about the need for our educational system to promote deeper learning and the development of 21st-century skills. Missing from the discourse is recognition that much of what we know from research on learning and instruction has yet to affect the design and enactment of everyday schooling in the form of curriculum, instruction, and assessment. This article considers some of the key research-based principles on learning and knowing and their implications for the design of instruction and assessment. Among these principles are differences in naïve and expert forms of knowing and how the latter develops through a variety of instructional methods and materials. Another is the social nature of learning and the classroom instructional and assessment practices that support students taking control of and monitoring their own learning. Incorporating many of the findings from research on learning and instruction into the materials, structures, and practices of everyday schooling involves addressing systemic challenges of practice and policy. These include the development and implementation of curricular and instructional resources that incorporate proven, research-based features, the design of assessment systems that balance and align classroom assessment and system monitoring needs, and more effective approaches to teacher preparation and professional development. The knowledge base to support such changes exists but for research-based educational interventions to move beyond isolated promising examples and to flourish more widely, these larger systemic issues, many of them policy driven, will need to be addressed.

Keywords

learning, instruction, assessment, sociocultural, cognition

Tweet

Designing Education for Deep Learning: Use Research Evidence about What to teach, How to teach it, and How to know if they learned it.

Key Points

- Citizens of the 21st century need to be flexible problem solvers who can adapt what they know for use in novel situations.
- Research on how people learn provides principles for revamping education systems to produce citizens for the 21st century.
- Changes to curriculum, instruction, and assessment need to build on the knowledge and beliefs students bring to learning situations.
- Learning is inherently interpersonal and benefits from collaboration as well as active self-monitoring and self-regulation processes.
- Classroom instruction needs to promote student agency and identity-as-learners through classroom discussion, challenging tasks, and ongoing formative assessment that provides feedback to guide the learning process.

Introduction

Business leaders, educational organizations, and researchers are calling for new education policies that target the development of broad, transferable skills and knowledge, often referred to as "Deeper Learning" and/or "21st century skills" (e.g., see Ananiadou & Claro, 2009; Bellanca, 2014; Pellegrino & Hilton, 2012). In response, the United States and other countries are generating new standards for educational outcomes. These are intended to produce "college and career ready" young adults

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(e.g., Common Core State Standards Initiative, 2010a, 2010b). Along with new standards are new assessments (Partnership for Assessment of Readiness for College and Careers, 2014; Smarter Balanced Assessment Consortium, 2014). Underlying the new standards and assessments is the claim that knowledge in the form of memorized facts and rote procedures is inadequate to support flexible, creative, and innovative problem solving or responding in new situations. Rather, in new situations, people need knowledge that helps them understand when, how, and why to apply what they know, so that they can appropriately use it (Pellegrino & Hilton, 2012). National and international assessments such as NAEP (National Assessment of Educational Progress) and PISA (Programme for International Student Assessment) indicate that many educational systems fall short in equipping graduates with these competencies (National Center for Educational Statistics, 2012; Organisation for Economic Co-Operation and Development, 2010; Rampey, Dion, & Donahue, 2009; Vanneman, Hamilton, Baldwin Anderson, & Rahman, 2009).

The imposition of new standards and assessments alone will not address the gap between the status quo and what is needed. Currently, most educational systems are poorly equipped to fulfill 21st-century needs. A major reason for this is outmoded perspectives on how people learn and how instruction and assessment can be designed and productively used in the service of learning. Research on learning and instruction conducted over the past 60 years provides important principles that should inform the design and evaluation of contemporary learning environments.

Principles of Learning and Instruction

Traditional approaches to what we teach—the curriculum; how we teach it—instruction; and how we evaluate what is learned—assessment, are based on theories and models of learning that have not kept pace with modern knowledge of how people learn. They fail to acknowledge what we know about the cognitive, social, and cultural dimensions of learning (Bransford, Brown, & Cocking, 2000; Nasir, Rosebery, Warren, & Lee, 2006; Pellegrino & Hilton, 2012). Furthermore, while general principles of learning (e.g., laws of repetition, practice, and feedback) are broadly applicable to all subject-matter areas (e.g., Pashler et al., 2007), it is critical to take into account disciplinary differences in content, organization, and knowledge generation practices. Such disciplinary differences have important implications for what is taught, how it is taught, and how it is assessed (Goldman, 2012; Moje, 2008). In what follows, we review major findings from research on principles of learning, instruction, and assessment and their implications for what is taught, how, and roles for assessment.

Research-Based Principles of Learning

While there are many important findings on learning, we highlight four principles that have particular significance for the design of curriculum, instruction, and assessment.

First, students do not come to classroom learning situations as "blank" slates. Rather they bring conceptions of themselves and their worlds that include beliefs, knowledge, and language and discourse practices. These conceptions come from various experiences in their homes, communities, and prior schooling. People's conceptions, or funds of knowledge (Moll & Greenberg, 1990), shape how people frame learning situations, their roles in them, efforts they are willing to invest in learning, and ultimately what they learn. Educational efforts need to acknowledge and build on learners' conceptions, so that they have opportunities to notice and confront consistencies and inconsistencies and engage in productive knowledge integration (Gutiérrez, Baquedano-López, Alvarez, & Chiu, 1999; Moje et al., 2004). Thus, a critical feature of effective teaching is that it elicits students' preexisting understandings of subject matter and provides opportunities to build on, or challenge, them.

Indeed, research on early learning suggests beginning in the preschool years because children develop sophisticated understandings of many of the phenomena around them. Sometimes, those understandings align with generally accepted ideas and provide a foundation for building new knowledge. But sometimes, they are incomplete and/or inconsistent with established principles. For example, in science, students often have conceptions of physical properties that cannot be easily observed and that are at variance with scientifically accepted conceptions (e.g., atoms do not move in solids; Duit, 2004). In humanities, preconceptions often include stereotypes or simplifications, as when history is understood as a cut and dried struggle between good and evil (Gardner, 1991). If the conceptions that students hold are not brought into the learning situation, they may fail to grasp new concepts, and preexisting conceptions remain their "go to" understandings.

It is also the case that existing understandings can bridge between in-school and out-of-school knowledge and sense-making practices (e.g., Gutiérrez et al., 1999). For example, Lee (2007) developed the cultural modeling approach as a means of making the structure of a domain visible and explicit to students. Using everyday texts such as rap songs, Lee asked high school students to be explicit about not only what the song meant but also how they knew that it was not to be taken simply at a literal level. Making the processes explicit for distinguishing literal from symbolic meaning in everyday discourse facilitates using these interpretive processes with the texts of formal schooling.

Making everyday content and process knowledge visible is not always sufficient for constructing new conceptions. Numerous research studies demonstrate the persistence of preexisting understandings even after a new model has been taught that contradicts the naïve understanding. For example, students at a variety of ages persist in their beliefs that seasons are caused by the earth's distance from the sun rather than by the tilt of the earth despite instruction to the contrary (Duit, 2004). For the scientifically accepted understanding to

replace the naïve understanding, students must reveal the latter and have the opportunity to see where it falls short.

The second principle about how people learn is that the content and organization of knowledge matter. To develop competence in an area of inquiry, students must (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application. This principle emerges from research that compares the performance of experts and novices, and from research on learning and transfer (e.g., Bransford et al., 2000). Experts, regardless of the field, always draw on richly structured information; they are not just "good thinkers" or "smart people"; nor do they necessarily have better overall memories than other people.

In their domain of expertise, experts do know *more* facts than other people but more crucial is that the facts are connected and organized into patterns, or schemas, that are meaningful for the content domain (Ericsson, Charness, Feltovich, & Hoffman, 2006). Organization of the facts according to important domain principles and frameworks transforms factual information into "usable knowledge" and reflects deep understanding. These organizational patterns, frameworks, or schemas allow experts to see patterns, relationships, or discrepancies that are not apparent to novices. They play an important role in experts' abilities to plan a task, generate reasonable arguments and explanations, and draw analogies to other problems. Experts' schematized conceptual understanding allows them to extract a level of meaning from information that is not apparent to novices (Chi, Glaser, & Rees, 1982). This helps them select and remember relevant information. Experts are also able to fluently access relevant knowledge because their understanding of subject matter allows them to quickly identify what is relevant.

Furthermore, organizing information into a conceptual framework allows for greater transfer: Students can apply what was learned to new situations and learn related information more quickly (Schwartz, Bransford, & Sears, 2005). Students who have learned geographical information for the Americas in a conceptual framework approach the task of learning the geography of another part of the globe with questions, ideas, and expectations that help guide acquisition of the new information. For example, understanding the geographical importance of the Mississippi River sets the stage for students' inquiry into the geographical importance of the Nile, the Rhine, or the Yangtze. Understanding why rivers are geographically important connects geography to other important systems of civilizations (e.g., economics, politics, social structures). As schematic webs become elaborated and embellished, they increasingly guide what learners attend to, and observe, ask questions and make inferences about, and notice as violations of expectations. For example, why did some cities and countries develop rapidly and prosper but others did not?

An important implication of expertise research is that to support transfer, curriculum and instruction need to emphasize the conceptual organization of knowledge and "big ideas" in a discipline. This emphasis should be present from the earliest stages of learning onward (National Research Council, 2012).

Third, learning is enhanced when people engage in thinking about their own thinking and learning, a process referred to as metacognition. Metacognition is an active process of monitoring how learning is going: what is understood, what is not; what fits to current conceptions and what does not; what questions are answered; whether progress toward learning goals is being made. Metacognition also refers to what learners know about their own learning processes (e.g., What strategies are useful in what situations?) and how they evaluate their own performance, the learning task and materials (Azevedo & Aleven, 2010). Metacognition is instrumental in students taking control of their own learning because it helps them define and monitor progress toward learning goals, select strategies to enhance learning, evaluate their progress toward the goal, and select alternate strategies when obstacles are encountered. Research with experts who were asked to verbalize their thinking as they worked revealed that they monitored their own understanding carefully, making note of when additional information was required and whether new information was consistent with what they already knew (e.g., Wineburg, 1994). Metacognitive activities are an important component of adaptive expertise, the ability to solve novel as well as routine problems (Hatano & Inagaki, 1986).

Metacognition and many of the strategies we use for thinking reflect cultural norms and methods of inquiry. They are acquired in social interaction and through observation of the behavior of others, including their verbalizations, gestures, and emotional displays. Research has demonstrated that children can be taught these strategies, including the ability to predict outcomes, explain to oneself to improve understanding, note failures to comprehend, activate background knowledge, plan ahead, and apportion time (Bransford et al., 2000). Metacognitive activities must be incorporated into the subject matter that students are learning. Attempts to teach metacognition as generic strategies can lead to failure to transfer.

The fourth principle is that learning is fundamentally interpersonal, often occurring in and through social interactions. Even when individuals are learning in physical isolation from others, they rely on culturally transmitted "wisdom of the past," communicated through various material artifacts (e.g., written works; physical objects; visuals such as photographs; Vygotsky, 1978; Wertsch, 1991). Sometimes, people learn from more knowledgeable others by observing explicit modeling or demonstration (e.g., teachers, older siblings, parents; Rogoff, 2003; Rogoff & Angelillo, 2002). Other times learning occurs in collaborative, peer-to-peer interactions or through communities of practice (Gutiérrez & Rogoff, 2003; Lave, 1988). When learners collaborate, they make their thinking visible to one another, thereby sharing perspectives and strategies that may challenge and extend each other's thinking and understanding.

Research-Based Principles of Instruction

Instruction that is consistent with the four principles of learning delineated above requires a shift in the learner's role from passive recipient of knowledge to active participant in learning processes. The shift has been described as moving from transmission models to knowledge construction or generation models (Scardamalia & Bereiter, 2006).

Principles for the Design of Instruction

We outline two overarching principles for the design of instruction that will support the achievement of deep learning through knowledge construction. These principles summarize extensive bodies of learning sciences research on the cognitive, motivational, and sociocultural dimensions of learning in multiple curricular domains (Pellegrino & Hilton, 2012). Teaching consistent with these principles makes it more likely that students will develop organized systems of knowledge and general principles that support transfer. However, achieving deeper learning takes time and repeated practice. Thus, instruction aligned with these principles should begin in preschool and continue across all levels of learning, from kindergarten through college and beyond.

The first overarching design principle is that learning environments should promote agency and self-regulated learning. Agency and a sense of self-confidence as a learner are important predictors of achievement (Dweck & Master, 2009). This relationship may be due, in part, to learners being more willing to engage and persist at challenging tasks when they perceive themselves as competent, responsible, and accountable for regulating their own learning (Winne, 1995). Research (Wigfield & Eccles, 2000; Wigfield, Tonks, & Klauda, 2009) shows that students learn more deeply when they:

- attribute their performance to effort rather than to ability;
- have the goal of mastering the material rather than the goal of performing well or not performing poorly;
- expect to succeed on a learning task and value the learning task;
- believe that they are capable of achieving the task at hand.

How such environments are promoted is addressed at least in part by the second overarching design principle.

Second, contexts for learning should pose challenging tasks and provide guidance and supports that make the task manageable for learners. A variety of studies across language arts, mathematics, and science indicate that the cognitive demands of tasks have a systematic relationship to achievement: Those that make reasonable but high demands on thinking and reasoning show higher student achievement compared with low-demand tasks (e.g., Newmann & Associates, 1996; Stein & Lane, 1996). However, students cannot be expected to solve challenging problems without appropriate guidance and support. For example, there is no compelling evidence that beginners deeply learn science concepts or processes simply by freely exploring a science simulation or game. In contrast, asking students to solve challenging problems while providing specific social support and cognitive guidance does promote deeper learning. Social support in the form of various types of collaborative learning positively affects individual learning. Examples are peer-assisted learning (Fuchs, Fuchs, Mathes, & Simmons, 1997), problem-based learning (Hmelo-Silver, 2004), and team-based learning (Vaughn et al., 2013).

Cognitive guidance. Three major forms of cognitive guidance are classroom discourse, learning resources, and formative assessment.

Classroom discourse: Orchestrating talk. Associated with the transmission metaphor for teaching and learning is monologic discourse, otherwise dubbed the I–R–E sequence (Mehan, 1979): Teachers ask a question, they call on students and evaluate if it is the desired response. If so, they ask the next question. If not, they ask another student until someone provides the "right" response or they provide it themselves. Often the questions are "known answer" questions and the process is actually designed to test whether students have done the reading or memorized some set of facts. This form of monologic discourse can be contrasted with dialogic discourse (Wells, 1999), also referred to as instructional conversations (Goldenberg, 1992; Tharp & Gallimore, 1988) and accountable talk (Michaels, O'Connor, & Resnick, 2008): Teachers pose questions that encourage elaborations, questions, and explanations that require students to actively engage with the material. Dialogic discussions increase student talk and decrease teacher talk (Murphy, Wilkinson, Soter, Hennessey, & Alexander, 2009). Students transform content into their own words, connect it to their prior knowledge, initiate topics, make claims and counterclaims, support their claims with evidence, and pose new questions and puzzles that set the stage for further investigation. In literature classes, dialogic discourse is associated with students going beyond only comprehension of plot to adopting an interpretive stance (Applebee, Langer, Nystrand, & Gamoran, 2003). In both science and mathematics, having students discuss and explain different ways they solved the "same" problem leads to deeper conceptual understanding (O'Connor & Michaels, 1993, 1996).

Classroom discussion is also an effective vehicle for focusing students on *how* they know—the processes they are using to understand. Making these thinking processes explicit through classroom discussion validates and normalizes the process of thinking about thinking—metacognition (Lee, 2007; Schoenbach, Greenleaf, & Murphy, 2012). This becomes particularly important when students experience confusion or discrepancies between what their prior

knowledge led them to expect and the new information they are trying to understand. Discussion about what does *not* make sense as well as what does can provide opportunities for supporting learning that do not arise when the classroom norm is that you are supposed to know the answers to the questions. Thus, important as the cognitive outcomes are, dialogic classroom discussion also enhances agency in learning—the degree to which students take up the intellectual work of sense making (e.g., Nystrand & Gamoran, 1991).

Material learning resources. Guidance and support for success with challenging tasks also depend on the learning resources that are provided for students. "Knowledge-telling" materials such as textbooks that present static compendia of facts obscure the dynamic epistemological processes that produced the "facts" in the first place. A steady diet of such materials obscures the tentative nature of science, the disputed nature of historical arguments, and the legitimacy of multiple interpretations of the same poem, novel or song.

Deeper learning is fostered by learning resources that include multiple and varied representations of concepts. Research has shown that adding diagrams to a text or adding animation to a narration that describes how a mechanical or biological system works can increase students' performance on a subsequent problem-solving transfer test. In addition, allowing students to use concrete objects to represent arithmetic procedures has been shown to increase their performance on transfer tests. This finding has been shown both in classic studies in which bundles of sticks are used to represent two-column subtraction and in an interactive, computer-based lesson in which students move a bunny along a number line to represent addition and subtraction of numbers (Mayer, 2011).

Using examples and cases can help students see how a general principle or method is relevant to a variety of situations and problems. One approach is a worked-out example, in which a teacher models how to carry out a procedure—for example, solving probability problems—while explaining it step by step. Offering worked-out examples to students as they begin to learn a new procedural skill can help them develop deeper understanding of the skill. In particular, deeper learning is facilitated when the problem is broken down into conceptually meaningful steps that are clearly explained; the explanations are gradually taken away as students' proficiency increases with practice (Renkl, 2011).

Ongoing use of formative assessment. The third form of cognitive guidance is the ongoing use of assessment for learning. Assessment *for* learning, often labeled formative assessment, is distinguished from assessment *of* learning or summative assessment. At its best, formative assessment is closely tied to what is being taught—curriculum, and how it is being taught—instruction. Formative assessment is a process that is used throughout teaching and learning to monitor students' progress and adjust instruction when needed, to continually improve student learning. It is different from traditional "summative" assessments that measure what students have learned at the end of a set period of time.

Research indicates that teachers' use of formative assessment can significantly enhance learning by providing better and timely feedback to students about their learning (Black & Wiliam, 1998). The process of continuously monitoring students' learning progress allows teachers to clarify learning goals, respond adaptively based on individual learning patterns, and involve students in the process of peer- and self-assessment. Feedback available through formative assessment contributes to students' monitoring their own learning at a local level and can cue them to the need to adjust their learning activities. Such uses of formative assessment are grounded in research demonstrating that practice with informative feedback is essential for deeper learning and skill development, whereas practice without such feedback yields little learning (Shute, 2008).

Teachers can make use of formative information to plan, revise, or evaluate instructional activities and strategies. Materials for formative assessment are typically more informal than summative assessments (Heritage, 2010). For example, many teachers survey student thinking and understanding with "exit slips." These are short notes that typically indicate what students "took away" from a classroom lesson or activity and are handed to the teacher as students leave their class.

Ongoing formative assessment sits within a broader set of considerations regarding contemporary views of assessment. We assess students to find out what they know and can do, but assessments do not provide direct pipelines into students' minds. Unlike height or weight, the mental representations and processes educators care about are not outwardly visible. Thus, an assessment is a tool for generating observable evidence from which reasonable inferences can be drawn about what students know. Central to this entire process are theories, models, and data on how students learn and what students know as they develop competence.

Policy Implications

The principles of learning and instruction discussed above provide a means of aligning curriculum, instruction, and assessment. Alignment, in this sense, means that the three functions are directed toward the same ends and reinforce one another: Assessment should measure what and how students are actually being taught, and what is actually being taught should parallel the curriculum one wants students to master. Although this may seem straightforward, numerous reports over the last two decades indicate how challenging it is to achieve effective alignment among curriculum, instruction, and assessment (e.g., Bransford et al., 2000; Gordon Commission on the Future of Assessment in Education, 2013; National Academy of Education, 2009a, 2009b, 2009c, 2009d; National Center on Education and the Economy,

2007; Pellegrino, Chudowsky, & Glaser, 2001; Pellegrino & Hilton, 2012). Many of these reports have also argued that significant improvement is not a simple matter and will require changes to many elements of the education system. We outline the nature of such changes for curriculum and instruction, assessment, and teacher education and professional development.

Curriculum and Instruction

Further efforts are needed to create instructional materials and strategies that can be implemented by teachers in their classrooms and that can support teacher practice in ways that help students develop transferable knowledge and skills. Multiple stakeholder groups need to actively support the development and implementation of curriculum and instructional programs that incorporate principles of learning and research-based instructional methods such as those discussed earlier in this article.

Assessment

Despite research showing the value of ongoing formative assessment by teachers, current educational policies focus on summative assessments that measure mastery of limited forms of content knowledge and often hold schools and districts accountable for improving student scores on such assessments. This is at odds with a focus on the development of 21st-century knowledge and skills. However, recent policy developments in the United States suggest that both standards and assessments aligned with 21st-century skills are being entertained. For example, the Common Core State Standards in mathematics and English-language arts, the Framework for K-12 Science Standards, and the Next Generation Science Standards (Achieve, 2013) include many design facets well aligned with conceptions of deeper learning and 21st-century competencies (Pellegrino & Hilton, 2012).

However, the extent to which the educational goals articulated in these disciplinary standards and frameworks can be realized in educational settings will be strongly influenced by their inclusion in district, state, and national assessments. Because educational policy remains focused on outcomes derived from summative assessments that are part of accountability systems, teachers and administrators will focus instruction on whatever is included in state assessments. Thus, the new assessment systems adopted by states need to give significant attention to the inclusion of tasks and situations that focus on deep disciplinary knowledge and skills and that call upon a range of important 21st-century competencies.

A major challenge to attaining such a vision of assessment design and use involves political and economic forces influencing adoption. Traditionally, policymakers have favored the use of standardized, on-demand, end-of-year tests for purposes of accountability. Composed largely of selected response items, these tests are relatively cheap to develop, administer, and score; have sound psychometric properties; and provide easily quantifiable and comparable scores for assessing individuals and institutions. However, such standardized tests have not been conducive to measuring deeper learning or 21st-century competencies. In the face of current fiscal constraints at the federal and state levels, policymakers may seek to minimize assessment costs by maintaining lower cost, traditional test formats. They may resist incorporating into their systems relatively more expensive, richer performance- and curriculum-based assessments that may better measure 21st-century competencies.

Teacher Education and Professional Development

Current systems and programs will require major changes if they are to support teaching that encourages deeper learning. Changes will need to be made not only in the conceptions of what constitutes effective professional practice but also in the purposes, structure, and organization of preservice and professional learning opportunities (Darling-Hammond, 2006; Garrick & Rhodes, 2000; Lampert, 2010; Webster-Wright, 2009). In particular, disjointed teacher learning opportunities need to be replaced with more integrated continuums of teacher preparation, induction, support, and ongoing professional development, For example, Windschitl (2009; see also Wilson, 2011) proposed that teacher preparation programs should (a) center on a core curriculum grounded in a substantial knowledge of child or adolescent development, learning, and subject-specific pedagogy; (b) provide future teachers with extended opportunities to practice under the guidance of mentors for extended periods of time; and (c) integrate practice experiences with coursework.

Research to date has identified other characteristics of effective teacher preparation programs, including extensive use of case study methods, teacher research, performance assessments, and portfolio examinations that are used to relate teachers' learning to classroom practice (Darling-Hammond, 1999). Wilson (2011) and others have noted that one of the most promising practices for both induction and professional development involves bringing teachers together to analyze samples of student work, such as drawings, explanations, or essays, or to observe videotaped classroom dialogues for formative purposes. Working from principled analyses of how the students are responding to the instruction, the teachers can then change their instructional approaches accordingly.

More generally, policies and practices need to recognize the need for teachers to engage in ongoing learning that connects to their everyday lives in classrooms. That is, professional development needs to connect to the challenges that teachers experience as they implement new teaching approaches to cultivate students' 21st-century skills. Most

critically, preservice teachers and in-service teachers need opportunities to engage in the kinds of teaching and learning environments envisioned for their students. Experiencing instruction designed to support transfer will help them design and implement such environments in their own classrooms. Characteristics of such professional development include ongoing, active, and coherent opportunities to adopt an inquiry stance toward the teaching and learning process amid a professional community of learners (Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Kubitskey & Fishman, 2006). A policy challenge is finding the time within the workday for such activities and the recognition of these experiences as inherent to the job.

In reflecting on the implications of the research on learning and instruction discussed in this article, it is worth reminding ourselves that a more coherent system of curriculum, instruction, and assessment, one guided by contemporary theory and research on learning and knowing, could potentially reduce disparities in educational attainment. Doing so would allow a broader swathe of young people to enjoy the fruits of workplace success, improved health, and greater civic participation. However, important challenges remain in the areas of research, practice, and policy for attaining such outcomes. For educational interventions to move beyond isolated promising examples and to flourish more widely, larger systemic issues, many of them policy driven, will need to be addressed. These include the design of assessment systems, curricular and instructional resources that incorporate research-based features such as those described above, and more effective approaches to teacher preparation and professional development.

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References

Achieve. (2013). *Next generation science standards*. Available from http://www.nextgenscience.org/

Ananiadou, K., & Claro, M. (2009). *21st century skills and competences for new millennium learners in OECD countries*. Paris, France: OECD.

Applebee, A. N., Langer, J. A., Nystrand, M., & Gamoran, A. (2003). Discussion-based approaches to developing understanding: Classroom instruction and student performance in middle and high school English. *American Educational Research Journal*, *40*, 685-730.

Azevedo, R., & Aleven, V. (Eds.). (2010). *International handbook of metacognition and learning technologies*. Amsterdam, The Netherlands: Springer.

Bellanca, J. (2014). *Deeper learning: Beyond 21st century skills*. Bloomington, IN: Solution Tree Press.

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education*, *5*, 7-74.

Bransford, J. D., Brown, A., & Cocking, R. (Eds.). (2000). *How people learn: Brain, mind, experience and school* (Expanded ed.). Washington, DC: National Academies Press.

Chi, M. T. H., Glaser, R., & Rees, E. (1982). Expertise in problem solving. In R. J. Sternberg (Ed.), *Advances in the psychology of human intelligence* (Vol. 1, pp. 7-75). Hillsdale, NJ: Lawrence Erlbaum.

Common Core State Standards Initiative. (2010a). *English language arts standards*. Washington, DC: National Governors Association and Council of Chief State School Officers.

Common Core State Standards Initiative. (2010b). *Mathematics standards*. Washington, DC: National Governors Association and Council of Chief State School Officers. Retrieved from http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf

Darling-Hammond, L. (1999). Target time toward teachers. *Journal of Staff Development*, *20*, 31-36.

Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education*, *57*, 1-15.

Desimone, L. M., Porter, A. S., Garet, M. S., Yoon, K. S., & Birman, B. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis*, *24*, 81-112.

Duit, R. (2004). *Bibliography: Students' and teachers' conceptions and science education database*. Kiel, Germany: University of Kiel.

Dweck, C. S., & Master, A. (2009). Self-theories and motivation: Students' beliefs about intelligence. In K. R. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 123-140). New York, NY: Routledge.

Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (Eds.). (2006). *The Cambridge handbook of expertise and expert performance*. New York, NY: Cambridge University Press.

Fuchs, D., Fuchs, L. S., Mathes, P. G., & Simmons, D. C. (1997). Peer-assisted learning strategies: Making classrooms more responsive to diversity. *American Educational Research Journal*, *34*, 174-206.

Gardner, H. (1991). *The unschooled mind: How children think and how schools should teach*. New York, NY: Basic Books.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*, 915-945.

Garrick, J., & Rhodes, C. (2000). *Research and knowledge at work: Perspectives, case studies, and innovative strategies*. London: Routledge.

Goldenberg, C. (1992). Instructional conversations: Promoting comprehension through discussion. *The Reading Teacher*, *46*, 316-326.

Goldman, S. R. (2012). Adolescent literacy: Learning and understanding content. *Future of Children*, *22*, 89-116.

Gordon Commission on the Future of Assessment in Education. (2013). *Policy report*. Retrieved from http://www.gordoncommission.org/publications_reports.html

Gutiérrez, K., Baquedano-López, P., Alvarez, H., & Chiu, M. M. (1999). Building a culture of collaboration through hybrid language practices. *Theory Into Practice*, *38*, 87-93.

Gutiérrez, K., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational Researcher*, *32*(5), 19-25.

Hatano, G., & Inagaki, K. (1986). Two courses of expertise. In H. A. H. Stevenson, H. Azuma, & K. Hakuta (Eds.), *Child development and education in Japan* (pp. 262-272). New York, NY: Freeman.

Heritage, M. (2010). *Formative assessment: Making it happen in the classroom*. Thousand Oaks, CA: Corwin Press.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*, 235-266.

Kubitskey, B., & Fishman, B. J. (2006). A role for professional development in sustainability: Linking the written curriculum to enactment. In S. A. Barab, K. E. Hay, & D. T. Hickey (Eds.), *Proceedings of the 7th International Conference of the Learning Sciences* (Vol. 1, pp. 363-369). Mahwah, NJ: Lawrence Erlbaum.

Lampert, M. (2010). Learning teaching in, from, and for practice: What do we mean? *Journal of Teacher Education*, *61*, 1-2.

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

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

Mayer, R. E. (2011). Instruction based on visualizations. In R. E. Mayer & P. A. Alexander (Eds.), *Handbook of research on learning and instruction* (pp. 427-445). New York, NY: Routledge.

Mehan, H. (1979). *Learning lessons: Social organization in the classroom*. Cambridge, MA: Harvard University Press.

Michaels, S., O'Connor, C., & Resnick, L. B. (2008). Deliberative discourse idealized and realized: Accountable talk in the classroom and in civic life. *Studies in Philosophy and Education*, *27*, 283-297.

Moje, E. B. (2008). Foregrounding the disciplines in secondary literacy teaching and learning: A call for change. *Journal of Adolescent and Adult Literacy*, *52*, 96-107.

Moje, E. B., Ciechanowski, K. M., Kramer, K. E., Ellis, L., Carrillo, R., & Collazo, T. (2004). Working toward third space in content area literacy: An examination of everyday funds of knowledge and discourse. *Reading Research Quarterly*, *39*, 38-70.

Moll, L. C., & Greenberg, J. (1990). Creating zones of possibilities: Combining social contexts for instruction. In L. C. Moll (Ed.), *Vygotsky and education* (pp. 319-348). New York, NY: Cambridge University Press.

Murphy, P. K., Wilkinson, I. A. G., Soter, A. O., Hennessey, M. N., & Alexander, J. F. (2009). Examining the effects of classroom discussion on students' comprehension of text: A meta-analysis. *Journal of Educational Psychology*, *101*, 740-764.

Nasir, N. S., Rosebery, A. S., Warren, B., & Lee, C. D. (2006). Learning as a cultural process: Achieving equity through diversity. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 489-504). New York, NY: Cambridge University Press.

National Academy of Education. (2009a). *Education policy white paper on science and mathematics education* (J. Kilpatrick & H. Quinn, Eds.). Washington, DC: Author.

National Academy of Education. (2009b). *Education policy white paper on standards, assessments, and accountability* (L. Shepard, J. Hannaway, & E. Baker, Eds.). Washington, DC: Author.

National Academy of Education. (2009c). *Education policy white paper on teacher quality* (S. Wilson, Ed.). Washington, DC: Author.

National Academy of Education. (2009d). *Education policy white paper on time for learning* (B. Rowan, Ed.). Washington, DC: Author.

National Center for Educational Statistics. (2012). *The nation's report card: Science 2011* (NCES 2012-465). Washington, DC: Institute of Education Sciences, U.S. Department of Education.

National Center on Education and the Economy. (2007). *Tough choices or tough times*. Washington, DC: Author.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas* (Committee on a Conceptual Framework for New K-12 Science Education Standards, Board on Science Education, Division of Behavioral and Social Sciences and Education). Washington, DC: The National Academies Press.

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

Nystrand, M., & Gamoran, A. (1991). Student engagement: When recitation becomes conversation. In H. C. Waxman & H. J. Walberg (Eds.), *Effective teaching: Current research* (pp. 257-276). Berkeley, CA: McCutchan.

O'Connor, M. C., & Michaels, S. (1993). Aligning academic task and participation status through revoicing: Analysis of a classroom discourse strategy. *Anthropology and Education Quarterly*, *24*, 318-335.

O'Connor, M. C., & Michaels, S. (1996). Shifting participant frameworks: Orchestrating thinking practices in group discussion. In D. Hicks (Ed.), *Discourse, learning, and schooling* (pp. 63-103). New York, NY: Cambridge University Press.

Organisation for Economic Co-Operation and Development. (2010). *PISA 2009 results: What students know and can do: Student performance in reading, mathematics, and science*. Paris: Author.

Partnership for Assessment of Readiness for College and Careers. (2014). *The PARCC assessment: Item development*. Retrieved from http://www.parcconline.org/assessments/test-design/test-development/item-development

Pashler, H., Bain, P. M., Bottge, B. A., Graesser, A., Koedinger, K., McDaniel, M., & Metcalfe, J. (2007). *Organizing instruction and study to improve student learning: IES practice guide* (NCER 2007-2004). Washington, DC: National Center for Education Research.

Pellegrino, J. W., Chudowsky, N., & Glaser, R. (Eds.). (2001). *Knowing what students know: The science and design*

of educational assessment. Washington, DC: National Academies Press.

Pellegrino, J. W., & Hilton, M. L. (Eds.). (2012). *Education for life and work: Developing transferable knowledge and skills in the 21st century*. Washington, DC: National Academies Press.

Rampey, B. D., Dion, G. S., & Donahue, P. L. (2009). *NAEP 2008 trends in academic progress* (NCES 2009-479). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Renkl, A. (2011). Instruction based on examples. In R. E. Mayer & P. A. Alexander (Eds.), *Handbook of research on learning and instruction* (pp. 272-295). New York, NY: Routledge.

Rogoff, B. (2003). *The cultural nature of human development*. New York, NY: Oxford University Press.

Rogoff, B., & Angelillo, C. (2002). Investigating the coordinated functioning of multifaceted cultural practices in human development. *Human Development*, *45*, 211-225.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 97-115). New York, NY: Cambridge University Press.

Schoenbach, R., Greenleaf, C. L., & Murphy, L. (2012). *Reading for understanding: How Reading Apprenticeship improves disciplinary learning in secondary and college classrooms*. New York, NY: Jossey-Bass.

Schwartz, D. L., Bransford, J. D., & Sears, D. (2005). Efficiency and innovation in transfer. In J. P. Mestre (Ed.), *Transfer of learning from a modern multidisciplinary perspective* (pp. 1-51). Greenwich, CT: Information Age.

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research*, *78*, 153-189.

Smarter Balanced Assessment Consortium. (2014). *The SBAC assessment: Item writing and review*. Retrieved from http://www.smarterbalanced.org/smarter-balanced-assessments/item-writing-and-review/

Stein, M. K., & Lane, S. (1996). Instructional tasks and the development of student capacity to think and reason: An analysis of the relationship between teaching and learning in a reform mathematics project. *Educational Research and Evaluation*, *2*(1), 50-80.

Tharp, R. G., & Gallimore, R. (1988). *Rousing minds to life*. Cambridge, UK: Cambridge University Press.

Vanneman, A., Hamilton, L., Baldwin Anderson, J., & Rahman, T. (2009). *Achievement gaps: How black and white students in public schools perform in mathematics and reading on the National Assessment of Educational Progress* (NCES 2009-455). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Vaughn, S., Swanson, E. A., Roberts, G., Wanzek, J., Stillman-Spisak, S. J., Solis, M., & Simmons, D. (2013). Improving reading comprehension and social studies knowledge in middle school. *Reading Research Quarterly*, *48*, 77-93.

Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Webster-Wright, A. (2009). Reframing professional development through understanding authentic professional learning. *Review of Educational Research*, *79*, 702-739.

Wells, G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory of education*. Cambridge, UK: Cambridge University Press.

Wertsch, J. V. (1991). *Voices of the mind: A sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press.

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, *25*, 68-81.

Wigfield, A., Tonks, S., & Klauda, S. L. (2009). Expectancy-value theory. In K. R. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 55-76). New York, NY: Routledge.

Wilson, S. (2011, May 10-11). *Effective STEM teacher preparation, induction, and professional development*. Paper presented at the NRC Workshop on Highly Successful STEM Schools or Programs, Washington, DC.

Windschitl, M. (2009, February 5-6). *Cultivating 21st century skills in science learners: How systems of teacher preparation and professional development will have to evolve*. Paper commissioned for the NRC Workshop on Exploring the Intersection between Science Education and the Development of 21st Century Skills, Washington, DC.

Wineburg, S. S. (1994). The cognitive representation of historical texts. In G. Leinhardt, I. L. Beck, & C. Stainton (Eds.), *Teaching and learning in history* (pp. 85-135). Hillsdale, NJ: Lawrence Erlbaum.

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