HOW PEOPLE LEARN: BRAIN, MIND, EXPERIENCE & SCHOOL
By National Research Council, 2000

- At different points in history, scholars have worried that formal educational environments have been better at selecting talent than developing it.
- A logical extension of the view that new knowledge must be constructed from existing knowledge is that teachers need to pay attention to the incomplete understandings, the false beliefs, and the naïve renditions of concepts that learners bring with them to a given subject.
- This tale illustrates both the creative opportunities and dangers inherent in the fact that people construct new knowledge based on their current knowledge.
- A common misconception regarding "constructivist" theories of knowing (that existing knowledge is used to build new knowledge) is that teachers should never tell students anything directly but, instead, should always allow them to construct knowledge for themselves. This perspective confuses a theory of pedagogy with a theory of knowing. Constructivists assume that all knowledge is constructed from previous knowledge, irrespective of how one is taught – even listening to a lecture involves active attempts to construct new knowledge.

Key Findings

1. Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.
   - In science students often have misconceptions of physical properties that cannot be easily observed. In humanities, their preconceptions often include stereotypes or simplifications, as when history is understood as a struggle between good guys and bad guys.
2. 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.
   - A key finding in the learning and transfer literature is that organizing information into a conceptual framework allows for greater "transfer"; that is, it allows the student to apply what was learned in new situations and to learn related information more quickly.
3. A "metacognitive" approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.
   - Research has demonstrated that children can be taught these strategies, including the ability to predict outcomes, explain to oneself in order to improve understanding, note failures to comprehend, activate background knowledge, plan ahead, and apportion time and memory.
   - The teaching of metacognitive activities must be incorporated into the subject matter that students are learning. These strategies are not generic across subjects, and attempts to teach them as generic can lead to failure to transfer.

Implications for Teaching

1. Teachers must draw out and work with the preexisting understandings that their students bring with them.
   - Given the goal of learning with understanding, assessments must tap understanding rather than merely the ability to repeat facts or perform isolated skills.
2. Teachers must teach some subject matter in depth, providing many examples in which the same concept is at work and providing a firm foundation of factual knowledge.
   - In-depth study in a domain often requires that ideas be carried beyond a single school year before students can make the transition from informal to formal ideas. This will require active coordination of the curriculum across school years.

- Teachers must come to teaching with the experience of in-depth study of the subject area themselves.

3. The teaching of metacognitive skills should be integrated into the curriculum in a variety of subject areas.

Designing Classroom Environments

1. Schools and classrooms must be learner centered.
   - Cultural differences can affect students' comfort level in working collaboratively versus individually, and they are reflected in the background knowledge students bring to a new learning situation.
   - Students' theories of what it means to be intelligent can affect their performance. Research shows that students who think that intelligence is a fixed entity are more likely to be performance oriented than learning oriented – they want to look good rather than risk making mistakes while learning. Students who think that intelligence is malleable are more willing to struggle with challenging tasks; they are more comfortable with risk (Dweck, 1989)
2. To provide a knowledge-centered classroom environment, attention must be given to what is taught (information, subject mater), why it is taught (understanding), and what competence or mastery looks like.
   - Many curricula fail to support learning with understanding because they present too many disconnected facts in too short a time – the "mile wide, inch deep" problem.
3. Formative assessments – ongoing assessments designed to make students' thinking visible to both teachers and students – are essential. They permit the teacher to grasp the students' preconceptions, understand where the students are in the "developmental corridor" from informal to formal thinking, and design instruction accordingly.
4. Learning is influenced in fundamental ways by the context in which it takes place. A community-centered approach requires the development of norms for the classroom and school, as well as connections to the outside world, that support core learning values.
5. The norms established in the classroom have strong effects on students' achievement. In some schools, the norms could be expressed as "don't get caught not knowing something." Others encourage academic risk-taking and opportunities to make mistakes, obtain feedback and revise.

- In order for teachers to change their practices they need opportunities to try things out in their classrooms and then receive feedback.

How Experts Differ from Novices

1. Experts notice features and meaningful patterns of information that are not noticed by novices.
2. Experts have acquired a great deal of content knowledge that is organized in ways that reflect a deep understanding of their subject matter.
3. Experts' knowledge cannot be reduced to sets of isolated facts or propositions but, instead, reflects contexts of applicability: that is, the knowledge is "conditionalized" on a set of circumstances.
4. Experts are able to flexibly retrieve important aspects of their knowledge with little attentional efforts.
5. Though experts know their disciplines thoroughly, this does not guarantee that they are able to teach others.
6. Experts have varying levels of flexibility in their approach to new situations.

- Chess masters perceive chunks of meaningful information, which affects their memory for what they see. Chess maters are able to chunk together several chess pieces in a configuration that is governed by some strategic component of the game. Lacking a hierarchical, highly organized structure for the domain, novices cannot use this chunking strategy.
- In mathematics, experts are more likely than novices to first try to understand problems, rather than simply attempt to plug numbers into formulas.
- The fact that experts' knowledge is organized around important idea or concepts suggests that curricula should also be organized in ways that lead to conceptual understanding. Many approaches to curriculum design make it difficult for students to organize knowledge meaningfully.
- The idea of helping students organize their knowledge also suggests that novices might benefit from models of how experts approach problem solving – especially if they then receive coaching in using similar strategies.

- "Textbooks are much more explicit in enunciating the laws of mathematics or of nature than in saying anything about when these laws may be useful in solving problems.
- One way to help students learn about conditions of applicability is to assign word problems that require students to use appropriate concepts and formulas. If well designed, these problems can help students learn when, where, and why to use the knowledge they are learning.
- Automatic and fluent retrieval are important characteristics of expertise.
- An important aspect of learning is to become fluent at recognizing problem types in particular domains – such as problems involving Newton's second law or concepts of rate and functions – so that appropriate solutions can be easily retrieved from memory. The use of instructional procedures that speed pattern recognition are promising in this regard.
- Expertise in a particular domain does not guarantee that one is good at helping others learn it. In fact, expertise can sometimes hurt teaching because many experts forget what is easy and what is difficult for students.
- Shulman argues that pedagogical content knowledge is not equivalent to knowledge of a content domain plus a generic set of teaching strategies; instead, teaching strategies differ across disciplines. Expert teachers know the kinds of difficulties that students are likely to face; they know ho to tap into students' existing knowledge in order to make new information meaningful; and they know how to assess their students' progress.
- Young children often erroneously believe that they can remember information and hence fail to use effective strategies, such as rehearsal. The ability to recognize the limits of one's current knowledge then take steps to remedy the situation is extremely important for learners at all ages.
- Curricula that emphasize breadth of knowledge may prevent effective organization of knowledge because there is not enough time to learn anything in depth.
- The issue of retrieving relevant information provides clues about the nature of usable knowledge. Knowledge must be "conditionalized" in order to be retrieved when it is needed; otherwise, it remains inert. Many designs for curriculum, instruction and assessment practices fail to emphasize the importance of conditionalized knowledge. For example, texts often present facts and formulas with little attention to helping students learn the conditions under which they are most useful.
- Experts' ability to retrieve information effortlessly is extremely important because fluency places fewer demands on conscious attention which is limited in capacity. Effortful retrieval, by contrast, places many demands on a learner's attention: attentional effort is being expended on remembering instead of learning. Instruction that focuses solely on accuracy does not necessarily help students develop fluency.
- The six principles of expertise need to be considered simultaneously, as parts of an overall system. For example, the idea of promoting fluent access to knowledge must be approached with an eye toward helping students develop an understanding of the subject matter, learn when, where and how to use information and learn to recognize meaningful patterns of information. Furthermore, all these need to be approached from the perspective of helping students develop adaptive expertise which includes helping them become metacognitive about their learning so that they can assess their own progress and continually identify and pursue new learning goals.

Key Characteristics of Learning and Transfer

1. Initial learning is necessary for transfer, and a considerable amount is known about the kinds of learning experiences that support transfer.
2. Knowledge that is overly contextualized can reduce transfer; abstract representations of knowledge can help promote transfer.
3. Transfer is best viewed as an active, dynamic process rather than a passive end-product of a particular set of learning experiences.
4. All new learning involves transfer based on previous learning, and this fact has important implications for the design of instruction that helps students learn.

- The first factor that influences successful transfer is degree of mastery of the original subject. Without an adequate level of initial learning, transfer cannot be expected.

- Transfer is affected by the degree to which people learn with understanding rather than merely memorize sets of facts or follow a fixed set of procedures.
- Motivation affects the amount of time that people are willing to devote to learning. Humans are motivated to develop competence and to solve problems; they have, "competence motivation." Although extrinsic rewards and punishments clearly affect behavior, people work hard for intrinsic reasons, as well.
- Learners' tendencies to persist in the face of difficulty are strongly affected by whether they are "performance oriented" or "learning oriented". It is probable, but needs to be verified experimentally, that being "learning oriented" or "performance oriented' is not a stable trait of individual but, instead, varies across disciplines.
- One frequently used teaching technique is to get learners to elaborate on the examples used during learning in order to facilitate retrieval at a later time. The practice, however, has the potential of actually making it more difficult to retrieve the lesson material in other contexts, because knowledge tends to be especially context-bound when learners elaborate the new material with details of the context in which the material is learned.
- All of these strategies engage learners as active participants in their learning by focusing their attention on critical elements, encouraging abstraction of common themes or procedures (principles), and evaluating their own progress toward understanding.
- When people think about transfer, it is common to think first about learning something and then assessing the learner's abilities to apply it to something else. But even the initial learning phase involves transfer because it is based on the knowledge that people bring to any learning situation.
- Presenting a sophisticated explanation in science class, without also probing for students' preconceptions on the subject, will leave many students with incorrect understanding.
- To counteract these problems, teachers must strive to make students' thinking visible and find ways to help them reconceptualize faulty conceptions.
- The meanings that are attached to cultural knowledge are important in promoting transfer – that is, in encouraging people to use what they have learned. For example, story-telling is a language skill. Topic-associative oral styles have been observed among Black children. In contrast, white children use a more linear narrative style that more closely approximates the linear expository style of writing and speaking that schools teach. Judgments may be made by white and black teachers as they listen to these two language styles: white teachers find the topic-associative stories hard to follow and are much more likely to infer that the narrator is a low-achieving student; black teachers are more likely to positively evaluate the topic-associative style.
- One major contrast between everyday settings and school environments is that the latter place much more emphasis on individual work than most other environments.
- A second major contrast between schools and everyday settings is the heavy use of tools to solve problems in everyday settings, compared with "mental work" in school settings. The use of tools in practical environments helps people work almost error free.
- A third contrast is that abstract reasoning is often emphasized in school, whereas contextualized reasoning is often used in everyday settings. Reasoning can be improved when abstract logical arguments are embodied in concrete contexts.
- The transfer literature suggests that the most effective transfer may come from a balance of specific examples and general principles, not from either one alone.
- The amount and kind of initial learning is a key determinant of the development of expertise and the ability to transfer knowledge. Students are motivated to spend the time needed to learn complex subjects and to solve problems that they find interesting. Opportunities to use knowledge to create products and benefits for others are particularly motivating for students.
- Time spent learning for understanding has different consequences for transfer than time spent simply memorizing facts or procedures from textbooks or lectures.
- Knowledge that is taught in only a single context is less likely to support flexible transfer than knowledge that is taught in multiple contexts.
- Abstract representations of problems can also facilitate transfer.

- All new learning involves transfer. Previous knowledge can help or hinder the understanding of new information.
- Transfer from school to everyday environments is the ultimate purpose of school-based learning.
- Helping learners choose, adapt, and invent tools for solving problems is one way to facilitate transfer while also encouraging flexibility.
- A metacognitive approach to teaching can increase transfer by helping students learn about themselves as learners in the context of acquiring content knowledge. One characteristic of experts is an ability to monitor and regulate their own understanding in ways that allow them to keep learning adaptive expertise: this is an important model for students to emulate.
- Young children show positive biases to learn types of information readily and early in life. These forms of knowledge, referred to as privileged domains, center on broadly defined categories, notably physical and biological concepts, causality, number and language. Outside of these privileged domains learners must depend on will, ingenuity, and effort to enhance their learning.
- The child uses meaning as a clue to language rather than language as a clue to meaning.
- A traditional view of learning and development was that young children know and can do little, but with age and experience they become increasingly competent. From this view, learning is development and development is learning. There is no need to postulate special forms of learning or for learners to be particularly active. Yet even in privileged domains, this passive view does not fully apply.
- Scaffolding involves several activities and tasks, such as:
  - Interesting the child in the task
  - Reducing the number of steps required to solve a problem by simplifying the task, so that a child can manage components of the process and recognize when a fit with task requirements is achieved
  - Maintaining the pursuit of the goal, through motivation of the child and direction of the activity
  - Marking critical features of discrepancies between what a child has produced and the ideal solution
  - Controlling frustration and risk in problem solving
  - Demonstrating an idealized version of the act to be performed.
- Known-answer questions, where the interrogator has the information being request, occurred frequently in classroom dialogues. This privileges middle class white children. Black children experience little of these rituals in home experiences.
- A widely held misconception is that people use only 20% of their brains and should be able to use more of it. This belief appears to have arisen from the early neuroscience finding that much of the cerebral cortex consists of "silent areas" that are not activated by sensory or motor activity. However, it is now known that these silent areas mediate higher cognitive functions that are not directly coupled to sensory or motor activity.
- Learning changes the physical structure of the brain. These structural changes alter the functional organization of the brain; in other words, learning organizes and reorganizes the brain. Different parts of the brain may be ready to learn at different times.
- Learning/Intelligence is caused by nature or nurture? Genes vs. environment? A question that is much like asking which contributes most to the area of a rectangle, its height or its width.
- Unlike synapse overproduction and loss, the process of synapse addition operates throughout the entire human life span and is especially important in later life. This process is not only sensitive to experience; it is actually driven by experience. Synapse addition probably lies at the base of some, or even most, forms of memory.
- Both the interactive presence of a social group and direct physical contact with the environment are important factors: animals placed in the enriched environment alone showed relatively little benefit; neither did animals place din small cage within the larger environment. Thus, the gross structure of the cerebral cortex was altered by exposure to opportunities for learning and by learning in a social context.
- Learning adds synapses; exercise does not. Different kinds of experience condition the brain in different ways.
- The active mind at work using inferencing processes to relate events. People "remember" words that are implied but not stated with the same probability as learned words.

- Memory processes treat both true and false memory events similarly and, as shown by imaging technologies, activate the same brain regions, regardless of the validity of what is being remembered. Experience is important for the development of brain structures, and what is registered in the brain as memories of experiences can include one's own mental activities.
- One of the primary differences between the novice and the expert is the manner in which information is organized and utilized.

Findings:

1. The functional organization of the brain and the mind depends on and benefits positively from experience.
2. Development is not merely a biologically driven unfolding process, but also an active process that derives essential information from experience.
3. Research has shown that some experiences have the most powerful effects during specific sensitive periods, while others can affect the brain over a much longer time span.
4. An important issue that needs to be determined in relation to education is which things are tied to critical periods (e.g. some aspects of phonemic perception and language learning) and for which things is the time of exposure less critical.

- The idea of a classroom where young women, poor and minority students, and learning disabled students all read (not recite) and write about (not copy) Shakespeare or Steinbeck is a radical and hopeful departure from the long-running conception of literacy as serviceable skills for the many and generative, reflective reading and writing for the few.
- Learning Environments
  1. Learner-Centered
  2. Knowledge-Centered
  3. Assessment-Centered
  4. Community-Centered
- We use the term "learner centered" to refer to environments that pay careful attention to the knowledge, skills, attitudes and beliefs that learners bring to the educational setting.
- Diagnostic teaching provides an example of starting from the structure of a child's knowledge. The information on which to base a diagnosis may be acquired through observation, questioning and conversation, and reflection on the products of student activity.
- Learner-centered instruction also includes sensitivity to the cultural practices of students and the effect of those practices on classroom learning.
- Learner-centered environments include teachers who are aware that learners construct their own meanings, beginning with the beliefs, understandings, and cultural practices they bring to the classroom. If teaching is conceived as constructing a bridge between the subject matter and the student, learner-centered teachers keep a constant eye on both ends of the bridge.
- Environments that are solely learner-centered would not necessarily help students acquire the knowledge and skills necessary to function effectively in society.
- Knowledge-centered environments intersect with learner-centered environments when instruction begins with a concern for students' initial pre-conceptions about the subject matter.
- Knowledge-centered environments also focus on the kinds of information and activities that help students develop an understanding of disciplines.
- There are interesting new approaches to the development of curricula that support learning with understanding and encourage sense making. One is "progressive formalization" which begins with the informal ideas that students bring to school and gradually helps the see how these ideas can be transformed and formalized. Instructional units encourage students to build on their informal ideas in a gradual but structured manner so that they acquire the concepts and procedures of a discipline.
- Central to curriculum frameworks such as "progressive formalization" are questions about what is developmentally appropriate to teach at various ages.

- Older views that young children are incapable of complex reasoning have been replaced by evidence that children are capable of sophisticated levels of thinking and reasoning when they have the knowledge necessary to support these activities. An impressive body of research shows the potential benefit of early access by students to important conceptual ideas.
- To the Romans, a curriculum was a rutted course that guided the path of two-wheeled chariots. This rutted path metaphor is an appropriate description of the curriculum for many school subjects.
- An alternative to a "rutted path" curriculum is one of "learning the landscape". In this metaphor, learning is analogous to learning to live in an environment: learning your way around, learning what resources are available and learning how to use those resources in counting your activities productively and enjoyably.
- Traditional curricula often fail to help students "learn their way around" a discipline. The curricula include the familiar scope and sequence charts that specify procedural objectives to be mastered by students at each grade though an individual objective might be reasonable, it is not seen as part of a larger network. Yet it is the network, the connections among objective that is important. This is the kind of knowledge that characterizes expertise.
- An alternative to simply progressing through a series of exercises that derive from a scope and sequence chart is to expose students to the major features of a subject domain as they arise naturally in problem situations.
- A challenge for the design of knowledge-centered environments is to strike the appropriate balance between activities designed to promote understanding and those designed to promote the automaticity of skills necessary to function effectively without being overwhelmed by attention requirements.
- One mathematics teacher consistently produced students who scored high on statewide examinations by helping students memorize a number of mathematical procedures that typically appeared on the examinations, but the students did not really understand what they were doing, and often could not answer questions that required an understanding of mathematics.
- New developments in the science of learning suggest that the degree to which environments are community centered is also important for learning. Especially important are norms for people learning from one another and continually attempting to improve.
- Different classrooms and schools reflect different sets of norms and expectations. For example, an unwritten norm that operates in some classrooms is never to get caught making a mistake or not knowing an answer. This norm can hinder students' willingness to ask questions when they do not understand the material or to explore new questions and hypotheses. For example, the norms in a mathematics class may be that mathematics is knowing how to compute answers; a much better norm would be that the goal of inquiry is mathematical understanding. Different norms and practices have major effects on what is taught and how it is assessed.
- Competition may create situations that impede learning. This is especially so if individual competition is at odds with a community ethic of individuals contributing their strengths to the community.
- If students spend one-third of their non-sleeping time outside of school watching television, this means that they spend more time watching television in a year than they spend in school.
- Television also provides images and role models that can affect how children view themselves, how they see others, attitudes about what academic subjects they should be interested in, and other topics related to person perceptions. These images can have both positive and negative effects.
- Different disciplines are organized differently and have different approaches to inquiry. The evidence needed to support a set of historical claims is different from the evidence needed to prove a mathematical conjecture, and both of these different from the evidence needed to test a scientific theory.
- Effective teachers need pedagogical content knowledge (knowledge about how to teach in particular disciplines) rather than only knowledge of a particular subject matter.
- Pedagogical content knowledge is different from knowledge of general teaching methods. Expert teachers know the structure of their disciplines, and this knowledge provides them with cognitive roadmaps that guide the assignments they give students, the assessments they use to gauge students' progress, and the questions they ask in the give and take of classroom life. In short, their knowledge of the discipline and their knowledge of pedagogy interact.

- Often assumptions about historical significance remain unarticulated in the classroom. This contributes to students' beliefs that their textbooks are *the* history rather than *a* history.
- Expert teachers have a deep understanding of the structure and epistemologies of their disciplines, combined with knowledge of the kinds of teaching activities that will help students come to understand the discipline for themselves.
- The time on task is a major indicator for learning and deliberate practice is an efficient way to promote expertise.
- These examples demonstrate the importance of deliberate practice and of having a "coach" who provides feedback for ways of optimizing performance. If students had simply been given problems to solve on their own, it is highly unlikely that they would have spent time efficiently.
- The bridging strategy attempts to bridge from students' correct beliefs (called anchoring conceptions) to their misconceptions through a series of intermediate analogous situations.
- Minstrell uses many research-based instructional techniques (e.g. bridging, making students' thinking visible, facilitating students' ability to restructure their own knowledge) to teach physics for understanding.
- The emphasis on establishing communities of scientific practice builds on the fact that robust knowledge and understandings are socially constructed through talk, activity, and interaction around meaningful problems and tools.
- Most schools spend only between 1 and 3 percent of their operating budgets for professional development, even with salaries factored in.
- Two-thirds of U.S. teaches state that they have no say in what or how they learn in the professional development opportunities provided to them in schools.
- Problems with pre-service education:
    1. Inadequate time: 4-year undergraduate degrees make it difficult for prospective elementary teachers to learn subject matter and for prospective secondary teachers to learn about the nature of learners and learning
    2. Fragmentation: The traditional program arrangement (foundations courses, developmental psychology sequence, methods courses, and field experiences) offers disconnected courses that novices are expected to pull together into some meaningful, coherent whole
    3. Uninspired teaching methods: Although teachers are supposed to excite students about learning, teacher preparation methods courses are often lectures and recitation. So, prospective teaches who do not have hands-on, minds-on experiences with learning are expected to provide these kinds of experiences for students
    4. Superficial curriculum: the need to fulfill certification requirements and degree requirements leads to programs that provide little depth in subject matter or in educational studies, such as research on teaching and learning. Not enough subject-matter courses are included in teachers' preparation.
- We assume that what is known about learning applies to teachers as well as their students. Yet teacher learning is a relatively new topic of research, so there is not a great deal of data about it.

Technologies can be used in five ways:

1. Bring exciting curricula based on real-world problems into the classroom
2. Providing scaffolds and tools to enhance learning
3. Giving students and teachers more opportunities for feedback, reflection and revision
4. Building local and global communities that include teachers, administrators, students, parents, practicing scientists, and other interested people
5. Expanding opportunities for teacher learning.

Key findings about how early cognitive abilities related to learning

1. Privileged domains: Young children actively engage in making sense of their worlds. In some domains, most obviously language, but also for biological and physical causality and number, they seem predisposed to learn

2. Children are ignorant but not stupid: Young children lack knowledge, but they do have abilities to reason with the knowledge they understand
3. Children are problem solvers and, through curiosity, generate questions and problems: Children attempt to solve problems presented to them, and they also seek novel challenges. They persist because success and understanding are motivating in their own right.
4. Children develop knowledge of their own learning capacities – metacognition – very early. This metacognitive capacity gives them the ability to plan and monitor their success and to correct errors when necessary
5. Children's natural capabilities require assistance for learning: children's early capacities are dependent on catalysts and mediation. Adults play a critical role in promoting children's curiosity and persistence by directing children's attention, structuring their experiences, supporting their learning attempts, and regulating the complexity and difficulty of levels of information for them.

People's ability to transfer what they have learned depends upon a number of factors:

1. People must achieve a threshold of initial learning that is sufficient to support transfer.
2. Spending a lot of time (time on task) in and of itself is not sufficient to ensure effective learning. Practice and getting familiar with subject matter take time, but most important is how people use their time while learning. Concepts such as "deliberate practice" emphasize the importance of helping students monitor their learning so that they seek feedback and actively evaluate their strategies and current levels of understanding.
3. Learning with understanding is more likely to promote transfer than simply memorizing information from a test or a lecture.
4. Knowledge that is taught in a variety of contexts is more likely to support flexible transfer than knowledge that is taught in a single context.
5. Students develop flexible understanding of when, where, why and how to use their knowledge to solve new problems if they learn how to extract underlying themes and principles from their learning exercises. Understanding how and when to put knowledge to use – known as conditions of applicability – is an important characteristic of expertise.
6. Transfer of learning is an active process. Learning and transfer should not be evaluated by "one-shot" tests of transfer.
7. All learning involves transfer from previous experiences.
8. Sometimes the knowledge that people bring to a new situation impedes subsequent learning because it guides thinking in wrong direction.

Competent and Expert Performance

1. Relevant knowledge helps people organize information in ways that support their abilities to remember.
2. Learners do not always relate the knowledge they possess to new tasks, despite its potential relevance. This 'disconnect" has important implications for understanding differences between usable knowledge (which is the kind of knowledge that experts have developed) and less-organized knowledge, which tends to remain "inert."
3. Relevant knowledge helps people to go beyond the information given and to think in problem representations, to engage in the mental work of making inferences, and to relate various kinds of information for the purpose of drawing conclusions.
4. An important way that knowledge affects performances is through its influences on people's representations of problems and situations. Different representations of the same problem can make it easy, difficult, or impossible to solve.
5. The sophisticated problem representations of experts are the result of well-organized knowledge structures. Experts know the conditions of applicability of their knowledge, and they are able to access the relevant knowledge with considerable ease.

6. Different domains of knowledge, such as science mathematics, and history, have different organizing properties. It follows therefore, that to have an in-depth grasp of an area requires knowledge about both the content of the subject and the broader structural organization of the subject
7. Competent learners and problem solvers monitor and regulate their own processing and change their strategies as necessary. They are able to make estimates and "educated guesses."
8. The study of ordinary people under everyday cognition provides valuable information about competent cognitive performances in routine settings. Like the work of experts, everyday competencies are supported by sets of tools and social norms that allow people to perform tasks in specific contexts that they often cannot perform elsewhere.

Conclusions About Learners

1. Effective comprehension and thinking require a coherent understanding of the organizing principles in any subject matter; understanding the essential features of the problems of various school subjects will lead to better reasoning and problem solving; early competencies are foundational to later complex learning; self-regulatory processes enable self-monitoring and control of learning processes by learners themselves.
2. Transfer and wide application of learning are most likely to occur when learners achieve an organized and coherent understanding of the material; when the situations for transfer share the structure of the original learning; when the subject matter has been mastered and practiced; when subject domains overlap and share cognitive elements; when instruction includes specific attention to underlying principles; and when instruction explicitly and directly emphasizes transfer.
3. Learning and understanding can be facilitated in learners by emphasizing organized, coherent bodies of knowledge (in which specific facts and details are embedded), by helping learners learn how to transfer their learning, and by helping them use what they learn.
4. In-depth understanding requires detailed knowledge of the facts within a domain. The key attribute of expertise is a detailed and organized understanding of the important facts within a specific domain. Education needs to provide children with sufficient mastery of the details of particular subject matter so that they have a foundation for further exploration within those domains.
5. Expertise can be promoted in learners. The predominant indicator of expert status is the amount of time spent learning and working in a subject area to gain mastery of the content. Secondarily, the more one knows about a subject, the easier it is to learn additional knowledge.

Conclusions About Teachers

1. Teachers need expertise in both subject matter content and in teaching
2. Teachers need to develop understanding of the theories of knowledge (epistemologies) that guide the subject-matter disciplines in which they work.
3. Teachers need to develop an understanding of pedagogy as an intellectual discipline that reflects theories of learning, including knowledge of how cultural beliefs and the personal characteristics of learners influence learning.
4. Teachers are learners and the principles of learning and transfer for student learners apply to teachers.
5. Teachers need opportunities to learn about children's cognitive development and children's development of thought (children's epistemologies) in order to know how teaching practices build on learner's prior knowledge.
6. Teachers need to develop models of their own professional development that are based on lifelong learning, rather than on an "updating" model of learning in order to have frameworks to guide their career planning.