Learning

Gary D. Phye

Iowa State University, Ames, Iowa, USA

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GLOSSARY

declarative knowledge Involves knowledge of facts, concepts, vocabulary, and the usual bits of information that are stored in memory.

formative assessment The observation or measurement of student learning outcomes prior to and during the learning experience. Formative evaluation provides a starting point for determining change as well as periodic assessment during the learning episode.

no child left behind (NCLB) Federal legislation that was enacted to redefine the manner in which federally supported programs are held accountable for the impact of educational interventions on all students in the classroom. Target behavior for defining impact is the improvement of academic achievement in mathematics, reading/literacy, and science.

pedagogy The art and science of teaching.

problem-solving transfer The ability of students to apply prior knowledge in the form of academic problem-solving strategies to new and novel problem situations in academic subject matter areas.

procedural knowledge This type of knowledge is observed in the classroom when students demonstrate the ability (knowing how) to combine, refine, incorporate, and accommodate (in the Piagetian sense) declarative knowledge so that it can be used in a course of action.

self-efficacy Personal beliefs concerning one's capabilities to organize and implement actions necessary to perform behaviors at designated levels (efficacy expectations).

self-regulation The process whereby students personally activate and sustain behaviors, cognitions, and affects, which are systematically oriented toward the attainment of learning goals.

strategic knowledge This type of knowledge is observed in the classroom when students demonstrate "knowing when" to use prior knowledge that is in the form of declarative and procedural knowledge. This type of knowledge is observed in problem-solving situations.

summative assessment The assessment that occurs at the end of an educational intervention or teaching episode. A comparison of formative and summative assessment is the basis for the determination of change.

Academic learning is receiving increased attention in the early 21st century. The educational shibboleth is "no child left behind." This federal mandate has impacted the nation in a way that will continue to reverberate for several years. At the classroom level, teaching practices are being impacted by the emphasis on accountability.
and impact measures that are being implemented. At the school district level, the accountability and impact data are to be used for policy analysis and to guide educational reform. The professional educator involved with the evaluation of educational practices and programs must produce credible data that meet the criteria of scientifically based evidence. In all cases, the target behavior for these efforts is the improvement of student achievement in reading, mathematics, and science. Assuming that we send our children to school to learn these academic subjects, we must also ask the questions, “what do we mean by academic learning and what are the processes by which students develop their knowledge of academic subjects?” These two questions serve as the focus of this article. Coming from the psychology side of educational psychology, the context is current research findings from the memory, cognition, and learning literature that have potential application to educational practices. Thus, it goes without saying that the perspective is “learner centered” and the unit of analysis includes both the individual and the group, as implied in the phrase “no child left behind.”

1. ACADEMIC LEARNING

Learning as a proper noun has so many meanings that it is almost impossible to communicate effectively without first adding a qualifying term. For example, in the applied setting we call the classroom, there are different types of learning theories and models. Some theories describe and explain motor learning that serves as the basis for motor skill development. In other cases, some learning theories focus on learning that serves as the basis for social skills development. However, the focus of this article is academic learning that relies on cognitive learning theories and information processing models to describe and explain the development of personal knowledge about the subject matter we teach in the classroom.

I use the term academic as a descriptive adjective to communicate in one sense something about the nature of the thinking and remembering processes a student must engage in to successfully interact with classroom academic demands. In a second sense, I also draw attention to the fact that the curriculum content we commonly refer to as literature, mathematics, and science has a logically organized structure that must be understood by the student. In other words, in addition to simply acquiring information in the form of vocabulary, facts, or concepts, these building blocks for personal knowledge must be organized in a manner consistent with the epistemological demands of the subject matter being taught. Examples include knowledge of the syntactical structure of the language in which a third-grade student is writing, the logic for translating and representing a fifth-grade math story problem as an equation to be solved with the use of appropriate solution algorithms, and the formal prepositional logic involved with the ability to use combinations and permutations when solving ninth-grade algebra problems. From these examples, it is readily apparent that academic learning is quite different from social learning or motor learning, which also play a major role in students’ efforts to adjust and cope with the demands of schooling.

2. LEARNING AS ENDURING CHANGE

Having identified academic learning in terms of a “type” of learning activity, a closer look at a commonly accepted definition of learning will serve as a means of considering what is frequently referred to as the learning process. In the third edition of Learning Theories: An Educational Perspective, Dale Schunk offers a suggestion. Although experts disagree about the precise nature of learning, the following is a general definition of learning that is consistent with a cognitive focus and captures the criteria most educational professionals consider central to learning: “Learning is an enduring change in behavior, or in the capacity to behave in a given fashion, which results from practice or other forms of experience” (Shuell, 1986, as cited in Schunk, 2000, p. 2).

There are three elements to Schuell’s definition of learning that deserve further attention (change, endurance, and practice) because these elements help define the level of analysis involved in the present use of the term personal knowledge. This level of analysis is also driving the new “no child left behind” (NCLB) legislated mandates. These mandates emphasize the idea that all children can learn, and the key to success according to NCLB mandates is in the assessment and analysis of learning from a scientifically based perspective. Within this context of academic learning our discussion of the construction of personal knowledge can be critically examined.

3. DEFINING ELEMENTS

Behavioral change or change in the capacity for behavior is basic to any attempt to distinguish between information
processing and learning. Daily, each of us processes information through contact with our environment as well as information retrieved from memory in the form of ideas, recollections, etc. However, some of this information processing is at a level that does not initiate change in our behavior or our capacity to adapt. Academic learning involves the development of new behaviors or capacities, not simply the replication of previous habits. Furthermore, the demonstration of change is not left to conjecture. Rather, change can only be demonstrated by measuring the behavior at two different points in time. Typically, this is prior to and following instruction.

Enduring change must have some permanency about it. In other words, the important elements of instruction to which a student is exposed should be remembered. In fact, our curricula in the public schools are designed around this primary assumption. Unfortunately, the empirical evidence for enduring change is scanty at best. In our discussion of personal knowledge, we focus on the individual learner as the unit of analysis, not the class as a whole. This is in fact the reason that the NCLB mandates are framed within a consideration of the individual student (no child left behind). This in no way ignores the fact that academic learning occurs in a group context. Rather, it focuses attention on both the individual and the collective we call a classroom. This makes common sense when one considers that the basis for knowledge permanency is the individual student's memory system.

Practice is an interesting concept in the academic community. A basketball coach teaching motor skills will tell you that "practice makes perfect," a music teacher will insist that students practice between lessons, and the school administration will stress the practice of civility and social behavior. However, the classroom teacher responsible for academic content frequently views practice as a "hit-or-miss" proposition that gets attention during seatwork or homework. Interestingly, although all these practice episodes can be observed in any school, the episode that typically lacks any organization or rationale is seatwork or homework.

Together, these three basic elements of our definition of academic learning stress the idea that academic learning is not a one-shot instructional experience. It is a process of acquiring new information, the refinement and organization of what is already known, and the successful use of that knowledge. Academic learning is the product of practice that provides the basis for relatively long-term change in one's personal knowledge. Ideally, this change increases students' ability to be successful as they move from grade to grade where the curriculum requires more complex and specialized forms of personal knowledge.

4. TYPES OF PERSONAL KNOWLEDGE CONSTRUCTION

The following discussion is based on a common theoretical assumption that pervades educational psychology: Cognitive change must occur as a student progresses through the curriculum in order to be successful. Jerome Bruner, in his discussion of the spiral curriculum, made this point. Still valid today, this assumption is frequently presented in the form of a hierarchical schema, from simple to the complex, in terms of both the cognitive processing demands made on students and the nature of the subject matter to be learned. The following discussion takes this form and reflects a prevailing attitude among educational psychologists that the construction of personal knowledge can be identified as falling within three major typologies: declarative knowledge (concepts and facts), procedural knowledge (strategies, procedures, and schemata), and strategic knowledge (expertise in academic problem solving).

The study of knowledge can take many forms. Within the context of academic learning, the following analysis is functional in nature and involves an information processing perspective. The functional nature of the following discussion involves addressing the "what" and "how" questions of personal knowledge construction. Phye (1997a) stated,

A particular value of the information processing perspective for the classroom teacher is the assumption that, while each student in the classroom will have a unique set of prior experiences that influences entry learning level, rate of learning, style of learning, and so forth, all nondisabled students in the classroom will be approaching the learning assignment with essentially the same set of processing components. Consequently, when learning is not successful, an assessment can be quickly conducted in order to determine cognitive processing strengths and weaknesses. (p. 53)

5. DECLARATIVE KNOWLEDGE

Basically, declarative knowledge involves those things teachers refer to as facts, vocabulary, concepts, etc. These bits and pieces of information are the building blocks for academic learning. These are the "basics" that
cut across all curriculum content areas. For the student, the construction process involves not only attending and remembering but also the bringing of meaning to this newly acquired information. By connecting new information with prior knowledge or using new information to refine what is already known, meaning is changing from the concrete to the complex.

Three examples make the point. Outside the classroom as well as in the primary grades, a commonly accepted mathematical fact is that $2 \times 2 = 4$. However, as one progresses through the mathematics curriculum, a part of any student’s academic learning involves the following refinement of prior knowledge. The $2 \times 2 = 4$ mathematical fact applies only in a base 10 mathematical system. Thus, $2 = 2 = 4$ may not be a fact in other mathematical systems. This mathematical fact is refined or deemed to be “true” only within a specific context. For most students, this refined knowledge would have little or no relevance outside the classroom.

The second example is a common classroom learning experience that is observed when dealing with concepts in science. During the early grades, the concept of “animal” is introduced and students typically use the term to mean a large group of “nonpeople living things” of one type or another. However, as science lessons progress, the student is challenged to refine this general concept into a more specific organizational system that includes people within the sub-category of mammals and that mammals are still animals. This bit of declarative knowledge refinement has both high academic relevance and relevance outside the classroom.

Having touched on examples from mathematics and science, the last example comes from early reading. As a child progresses from kindergarten to the fourth grade, vocabulary building, fluency in reading, phonetic awareness, word attack skills, and comprehension are reading skills that are practiced in oral reading groups. As these basic reading skills become integrated, a child’s reading performance improves. A primary goal of learning to read involves the ability to comprehend what is being read. One part of this process is taking individual words and their meanings and putting them together into sentences. Interestingly, in English many words have different meanings depending on whether they are used as a noun or a verb in a sentence. The word “desert” used as a noun means a dry, barren, often sandy region that can naturally support little or no vegetation. Desert used as a verb means to forsake or leave, especially when most needed. Obviously, the key to understanding the meaning of the word desert depends on having both meanings available and selecting the appropriate meaning based on the context (rest of the sentence).

Students process information every waking moment of their lives. Some of the information is organized and some is fragmented or organized around real-world survival skills. However, academic knowledge is a special case in which the organizational principles are unique to the subject matter being taught. Consequently, remembering becomes a valuable cognitive skill for any student. Thus, as we go back to our basic definition of academic learning, the emphasis on enduring change becomes more apparent. As learners, we remember facts and concepts not only so we can demonstrate the acquisition of new declarative knowledge but also so this new knowledge becomes prior knowledge to be added to and refined at a later point in time. The reading example described previously also demonstrated the vital role that memory plays in academic learning. The student who encounters the word desert must remember two different meanings and successfully retrieve from memory the appropriate meaning, depending on the cues provided by the rest of the sentence. The ability to do this fluently requires a great deal of practice so that the process of remembering meanings occurs almost automatically.

Reading fluency is a good example of an academic behavior that improves with practice and is a critical academic survival skill. By the intermediate grades, students are asked to take increasingly more responsibility for their own learning. Most classroom environments change at the middle school level and students are expected to acquire a great deal of their own declarative knowledge by reading texts, working through Web-based instructional modules, etc. This expectation on the part of educators suggests that students should be practicing their reading skills during the primary grades so that they can successfully adapt to the demands of the middle school.

6. THE ROLE OF PRACTICE

Although practice is an essential element of the learning process, a frequently asked question is, “Does practice make perfect?” It goes without saying that practice of some type is typically more beneficial than no practice. However, not all practice is equally effective. This statement is simply the recognition that practice plays an important role in two quite different ways. In terms of acquiring academic knowledge, repeated exposures or repetition provide the basis for memory storage that is critical for remembering. In terms of reading
vocabulary, the association of the word desert with its meaning and the remembering of this pairing will require several repetitions in order for the information to be stored in long-term memory. This may be accomplished with a simple practice strategy that involves developing a set of what were called “flash cards” when I was a youngster. However, to successfully retrieve and use the appropriate meaning across a number of different reading passages requires the successful application of prior knowledge. The ability to successfully apply one’s knowledge is really a disposition or personality characteristic. This disposition is also acquired through practice and has been identified by Albert Bandura as a sense of “self-efficacy” or competence. In other words, successful practice strategies involve both multiple exposures to the task and actively seeking potential applications of prior knowledge. This is a simple example of “training for transfer.”

7. PROCEDURAL KNOWLEDGE

Within the context of academic learning, procedural knowledge is demonstrated when a student can combine, organize, refine, or accommodate declarative knowledge so that a course of action can be taken. This is “knowing how” to use declarative knowledge (what one knows). Procedural knowledge in the classroom is what we commonly strive to teach and we ask our students to learn.

In teaching circles, constructivist or student-centered approaches to instruction place a great deal of emphasis on promoting procedural knowledge. This is frequently the case in the areas of science education and mathematics education. The caveat is that students must have a solid background of declarative knowledge in order to successfully move to a more complex level of cognitive processing. The cognitive processing that serves as the basis for procedural knowledge is domain specific. For example, if we think of algebra as a part of the mathematics domain, there are basic mathematical facts and concepts (declarative knowledge) that have been learned in earlier grades that serves as the foundation for success in algebra. However, in algebra we are also asked to take our prior knowledge about mathematics and use that knowledge to develop new rules, concepts, strategies, algorithms, etc. This is really a case of taking what we know and learning how to use that knowledge to develop new and more complex ways of thinking.

For example, by the time students reach middle school, where they usually take algebra, the teaching of reading shifts from a focus on teaching basic reading skills to using reading skills to promote self-directed learning in literacy. At this point in students’ academic careers, emphasis is on procedural knowledge involving “knowing how to read” in order to successfully perform other educational tasks (write a poem, give a persuasive speech, read a science or mathematics textbook, etc.). These complex academic tasks are built on the declarative knowledge any student remembers from the earlier grades. This is why remembering (memory storage and retrieval) is the key to academic learning because complex subject matter that students are asked to learn is always built of declarative knowledge and simpler forms of procedural knowledge.

These descriptions of our expectations for students as they progress through the primary and middle school grades again draw our attention to the key academic learning element of enduring change that is couched in practice (seatwork, homework, study hall, etc.). Interestingly, there is little evidence in the research literature that teachers systematically teach study skills. This means that teachers should not only present information in the classroom but also teach students how to use the information being conveyed. Thus, teachers must teach not only declarative knowledge (what) but also procedural knowledge (how). A position frequently taken by educational psychologists is that domain-specific procedural knowledge strategies must be a part of any teacher’s instructional repertoire.

8. STUDENT SELF-EFFICACY:
A SENSE OF COMPETENCY

Self-regulation or self-regulated learning emphasizes the motivational side of human behavior. As such, it is a complementary view of the information processing approach to academic learning. Metaphorically, cognitive theory and motivational theory are two sides of the “coin” called academic learning. Research efforts by educational psychologists studying self-regulation emphasize how learners direct their thoughts, feelings, and actions toward the attainment of their academic goals.

Bandura’s concept of self-efficacy was discussed previously within the context of study or practice. Generally speaking, self-efficacy is the exercise of control by the individual in the daily task of adapting to a complex environment. Self-regulation and the development of a sense of self-efficacy grow out of a complex interaction of behaviors, interpersonal factors,
and environmental demands. In the classroom, a simplified example involves teacher variables, curriculum demands, and students' sense of success with the curriculum being taught (math, reading, etc.). This sense of success translates on a personal level for the student as being competent in the subject being taught. Furthermore, the success breeds a sense of self-efficacy: "I can do this, I understand how to take what I already know and use it to learn more about this because I understand what it takes to get better." "I am a good reader." "I am good at math."

Self-efficacy was introduced earlier within the context of practice because of the position taken by Bandura that it is the demonstration of being competent (a good reader or good at math) that precedes the sense of self-efficacy. Over the long term (from kindergarten to grade 12), it is the sense of self-efficacy in academic subject matter areas that provides the motivational basis for successfully making the transition between procedural and strategic knowledge construction by a student.

This sense of self-efficacy is what sustains a student when academic problem solving becomes complex and difficult. When confronted with a complex academic problem, a successful problem solver has sufficient declarative knowledge to bring to the task; sufficient procedural knowledge to synthesize, integrate, and evaluate the declarative knowledge; and can strategically (knowing when) translate this into a successful solution for a specific problem. It is self-efficacy, the sense of being able to exercise personal control over the process of knowledge construction in an academic setting, that characterizes strategic knowledge.

9. STRATEGIC KNOWLEDGE

Strategic knowledge is viewed as an extension of declarative and procedural knowledge. Whereas declarative knowledge involves learning facts, concepts, etc. and procedural knowledge involves learning how to use declarative knowledge to construct domain-specific rules, algorithms, etc., strategic knowledge involves knowing when to use prior knowledge. In other words, when confronted with a novel or problem-solving situation, emphasis is on the retrieval of prior declarative and procedural knowledge that has been stored from long-term memory. When this type of information processing is successful, we observe academic learning behaviors such as problem solving in mathematics, critical thinking in science, or creative thinking in the writing of fiction. This last type of knowledge demonstrated as a learning outcome emphasizes the active construction of a learning outcome and places the student at the center of the teaching-learning process. In addition to reflecting a competency dimension, primary consideration is given to motivational aspects of academic learning. This involves helping students develop a disposition frequently referred to as intellectual curiosity or academic expertise.

The development of strategic knowledge may be based largely on student characteristics that are very difficult to teach. Furthermore, some students may simply have difficulty with this level of cognitive functioning because of their cognitive limitations or personality characteristics.

Regardless, a teacher should provide opportunities that foster the development of strategic knowledge for those students who are capable. Strategic knowledge is a primary learner outcome of a self-regulated learning process we frequently identify as academic problem solving. Academic problem solving is observed when students can take primary responsibility for demonstrating the learning outcomes of problem identification, problem representation, strategy construction, and solution verification (evaluation).

Emphasis is on the student taking responsibility for identifying a problem, representing the problem, developing a strategy for solving the problem, and then evaluating the success of the strategy employed. This academic problem-solving perspective has been a major contribution to the teaching literature that is based to a large extent on the research efforts of Richard Mayer. These stages of the problem-solving process can be taught in any of the previously identified academic areas (mathematics, science, and literature). Any self-regulated learning process places a premium on remembering—the use of prior knowledge. The student is responsible for knowing what, how, and when. As demonstrated by Barry Zimmerman and colleagues, if we are successful, some of our students will become self-regulated learners. The choice is theirs, and the reward will be ours.

10. IMPLICATIONS FOR KNOWLEDGE ASSESSMENT

The implications for pedagogical practice are again derived from our definition of academic learning. Consistent with the NCLB legislation, the focus is on every child. This calls for the recognition of individual
differences in the classroom. In a single classroom on any given day, some students will be dealing with the development of declarative knowledge in a subject area while others will be grappling with issues involving procedural knowledge. A few may even be working at the strategic knowledge level of construction. On a daily basis, this means that classroom teachers will have to be well grounded in both the subject matter being taught and effective teaching strategies. In addition, since change is the focus of our definition of academic learning, this means that when appropriate, teachers are responsible for guiding students from one level of knowledge construction to another. This is a long-term view and involves change over the academic year within a grade. Consequently, for future change to occur, the student must remember today’s lesson, which is tomorrow’s prior knowledge. The implications for practice are obvious since the effective use of memory storage and retrieval is not easily accomplished.

Formative and summative assessment of academic learning is required since enduring change can be verified only to the extent that it can be measured. As mentioned previously, measurement at a minimum of two points in time is required for the assessment of change. Furthermore, a classroom environment in which student progress is monitored effectively would require multiple assessment techniques. The major obstacle facing most teachers is the assessment issue. There are numerous sources available for teachers that provide the basis for developing assessment activities that measure declarative knowledge. Most of these activities involve the assessment of memory retention using standard teacher-made tests.

The assessment of procedural knowledge and strategic knowledge also requires the assessment of memory retention, but it must also include the assessment of a student’s ability to use the knowledge in a manner that reflects the transfer of higher order thinking skills (e.g., Bloom’s taxonomy). This means that the assessment will require evidence of strategy transfer or problem-solving transfer on the part of students. Thus, as we promote the development of procedural and strategic knowledge through the use of instructional practices that foster such thinking, we must not forget that assessment practices must align with the instructional efforts and the learning expectations we have for our students. In simple terms, there are two assessment questions we must ask ourselves as teachers: Do our students remember what we taught, and can they effectively use what they remember?

11. DEVELOPMENTAL AND INDIVIDUAL DIFFERENCES

A model for knowledge assessment is provided in Table I. As mentioned previously, declarative knowledge can be assessed in the traditional manner and is frequently a one-time occurrence. In contrast, procedural knowledge and strategic knowledge require both a measure of memory retention and a measure of transfer. This dual-assessment procedure is required because transfer is based on prior knowledge. If we simply measure transfer performance and transfer performance is poor or nonexistent, as teachers we cannot determine if our students fail because they cannot remember or because they cannot use their declarative knowledge. In other words, memory retention is a necessary but not sufficient condition for transfer. Thus, teaching for transfer is based on teaching for declarative knowledge but also involves helping students understand how and when to use their knowledge.

Having made a distinction between an assessment procedure for declarative knowledge and procedural or strategic knowledge in terms of single or dual assessment, a distinction is also to be made between the assessment of procedural and strategic knowledge. In contrast to procedural knowledge, the volitional nature of strategic knowledge was emphasized. During procedural

<table>
<thead>
<tr>
<th>Type of learning outcome</th>
<th>Memory retention performance</th>
<th>Transfer performance</th>
<th>Kind of knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonlearner</td>
<td>Poor</td>
<td>Poor</td>
<td>None</td>
</tr>
<tr>
<td>Non-problem solver</td>
<td>Good</td>
<td>Poor</td>
<td>Declarative</td>
</tr>
<tr>
<td>Guided problem solver</td>
<td>Good</td>
<td>Good</td>
<td>Procedural</td>
</tr>
<tr>
<td>Self-directed problem solver</td>
<td>Good</td>
<td>Good</td>
<td>Strategic</td>
</tr>
</tbody>
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knowledge assessment, if students can transfer procedural knowledge "when asked to do so," guided understanding is demonstrated. From a problem-solving transfer perspective, these students are demonstrating the last three stages (problem representation, strategy selection, and solution verification) of the aforementioned problem-solving process. Unfortunately, we lack information about problem identification. The assessment of strategic knowledge, where no teacher guidance is provided, provides information about students' ability to identify problems. Here, students must volitionally construct an awareness of what knowledge is appropriate, how that knowledge can be organized into a solution strategy, and when the strategies are to be employed. Such students not only demonstrate the learning outcome of understanding but also the characteristics of successful problem solvers. This distinction between the assessment of procedural and strategic knowledge must always be considered when developing performance assessments in the classroom.

12. CONCLUSION

The multiple assessment approach to promoting understanding and problem solving in the classroom is at the heart of the NCLB legislation. No child should be left behind as a nonlearner. Every child can learn to a level that is determined by the individual differences in the academic abilities each of us exhibit. The hope is that as teachers, we facilitate to the best of our ability the personal knowledge construction efforts of all our students.

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