ASSUME A SPHERICAL COW: AN EXAMINATION OF FOUR IMPLICIT LEARNING AND TEACHING ASSUMPTIONS

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ABSTRACT

Teaching and learning are complementary processes that are most effective when teachers and students employ compatible methods and when their goals are aligned. Four “spherical cows,” metaphors for implicit assumptions made about key teaching and learning concepts, are explored. Explicit conceptualizations, drawn from selected research and theory and based on the understanding that knowledge is internally constructed and individually organized, are presented for each assumption. The conceptualizations support compatible teaching and learning methods and promote an effective partnership.

Keywords: Knowledge Representation, Knowledge Construction, Learning Goals, Learning Skills, Teaching.

INTRODUCTION

A large commercial dairy hired a physicist to perform an efficiency study. Presenting the results, the physicist drew a large circle on the flip chart at the front of the boardroom and began, “Assume a spherical cow with milk uniformly distributed within.” Assumptions are not inherently bad. Problem solving and theory building often begin by assuming a set of plausible initial conditions or approximations, which simplify complex systems allowing them to be more succinctly described and better understood, permit approximate solutions to otherwise intractable problems, and offer efficient solutions where greater precision is unwarranted.

Although assumptions play important roles in extending knowledge and understanding, the role they play must be clear at all times. In simple cases, such as “assume a frictionless surface,” our everyday experience informs us that these are deliberate but useful simplifications. When an assumption is not obvious, its role must be explicitly exposed so that its impact on theory and practice can be examined and assessed. Spherical cows are assumptions that are made implicitly and that lie unexposed and unexamined in the shadows of our reasoning.

The following discussion also makes assumptions: It assumes first that a conception of knowledge provides a concrete goal for learning and for teaching. Although there are many kinds knowledge that can be learned in many ways and in many settings, the discussion focuses on the kind of knowledge necessary to solve problems and that is typically taught in academic or training settings.
It next assumes that learning is a partnership between the student and the teacher, and specifically, that learning is most efficient and effective when both partners understand and fulfill their respective roles based on principled techniques. As corollaries, it assumes that the partnership’s effectiveness is enhanced when teachers include basic learning concepts and techniques with the instruction, and when students are prepared to recognize and to leverage the features inherent in well-formed instruction. And finally, it assumes that the ultimate learning outcome is dominated by the student’s intention and that learning is greatly increased when the student establishes learning-oriented goals.

Four assumptions are explored through a lens of published research to produce a focused synthesis of compatible teaching and learning techniques. These techniques can help guide teachers to create effective knowledge-oriented instruction. Mayer (1999) observes that, “The knowledge construction approach to instructional design is based on several underlying values about the appropriate goals of instruction, including a focus on process as well as product, on transfer as well as retention, and on how to learn as well as what to learn” (p. 159). This observation suggests that the presented techniques can also yield complementary learning techniques.

The assumptions explored here are rarely made consciously, and, if asked, few students and fewer teachers would acknowledge them. Nevertheless, they are often made implicitly, by default, when the nature of knowledge and learning are taken for granted. The first step to solving the problems arising from these implicit assumptions, or “spherical cows,” is to bring them out of the shadows where they can be examined and either embraced or discarded.

ASSUMPTION 1: KNOWLEDGE EQUALS INFORMATION

Most novices and many veterans—both students and teachers—take the nature of knowledge, and therefore the goal of learning, for granted. Failing to recognize a distinction between knowledge and information inevitably results in practices that treat them as the same—practices that implicitly assume that knowledge equals information. However, Brown & Duguid (2000) distinguish the two by observing that information is a self-contained entity that may be picked up, passed around, stored, and externally represented. Alternatively, knowledge is attached to a person, the knower, and “is hard to pick up and hard to transfer. . . . Knowledge is something we digest rather than merely hold” (p. 120).

Two simple thought experiments suggest that the digestion process consists of organizing and structuring information. First, imagine the actions of people playing a game requiring them to hold and to play many cards: they typically organize the cards into meaningful groups. Next, image the task of identifying which cards are missing from a deck: again, most people solve this problem by first organizing the cards. More-formal experiments also suggest that knowledge is organized in groups or chunks. The first experiment (Miller, 1956) demonstrated that human short term memory has a limited capacity of about seven items. Although more recent research (Hulme & Roodenrys, 1995) suggests that the capacity of short term memory is also a function of long term memory and of the phonological representations of the remembered items, short term memory is nevertheless restricted to only a few items.
In the second experiment, de Groot (1966) briefly presented chess boards, with the pieces arranged in complex patterns, to players of various skill levels. The players then attempted to reconstruct the patterns from memory. When the patterns corresponded to actual game moves, experts could reconstruct the boards with considerable accuracy while novices could not; random patterns were recalled poorly by both groups. A subsequent experiment (Chase & Simon, 1973) validated de Groot’s results and further demonstrated that expert chess player’s short term memory capacity was not significantly greater than that of novices. The last result suggests that expertise involves more than just raw information.

Chase & Simon (1973) suggest that expert players perceive the pieces on a chess board as patterns and “encode the position [of each piece] into larger perceptual chunks, each consisting of a familiar subconfiguration of pieces” (p. 80). For example, an expert player may recognize the collective positions of several pieces as corresponding to “castling” the king and the rook, Figure 1. Although the final positions of some pieces involved in the move can vary slightly, the overall pattern is quite constrained. In this example, an expert player need only remember “castle on the queen’s side” while a novice will likely try to remember the location of each piece. Remembering the move as a pattern uses only one item of short term memory rather than one item per piece. An expert player reconstructs the board by applying the game rules to a relatively small number of patterns. Four conceptions of knowledge, each based on the idea that knowledge is stored as related chunks, clarify the distinction between knowledge and information.

Subsumption theory or meaningful learning is an early conception of knowledge organized as a hierarchy (a ranking of information into levels). Ausubel (1962) proposed that “rotely and meaningfully learned materials are organized much differently in consciousness and hence conform to quite different principles of learning and forgetting” (p. 215). Learning takes place when new information is incorporated or subsumed into a learner’s existing knowledge structures. The new information is subsumed at an anchor point, a level in the hierarchy, relative to its generality or specificity. In contrast, when information is learned rotely, it exhibits little structure. Learning may
begin rote but the knower must ultimately organize the information into a structure that reflects
the meaning inherent in real-world concepts.

A similar but more specific conception maintains that knowledge is organized as hierarchical trees
(Figure 1). This assumption is the starting point for a series of experiments (McKeithen, Reitman,
Rueter, & Hirtle, 1981; Naveh-Benjamin, McKeachie, Lin, & Tucker, 1986; Reitman & Rueter,
1980). In this conception, the leaves of the trees are the remembered information and the interior
nodes are summarizing concepts. The researchers algorithmically inferred tree structures from
data collected from research participants. Although the experiments were unable to establish that
people actually store knowledge as trees, they demonstrated a positive correlation between
expertise and the amount of structure in the inferred trees, and that people with similar levels of
expertise develop similar trees (McKeithen et al., 1981).

Schemas are a third conception that organizes the common features of similar concepts into fields
or attributes that characterize the concept. This organization may be viewed as a table where the
columns correspond to the fields and the rows to specific concepts. Complex concepts are
represented by schemas in which one or more fields are themselves schemas. “To interpret a
particular situation in terms of a schema is to match the elements in the situation with the generic
434). That is, when the specific features of an entity, situation, or concept match the fields of an
established schema, it is more deeply understood and more easily remembered than when the
learner does not have an existing schema or when the correspondence is poor.

Mental models are the fourth and most extensive conception of knowledge organization. “A mental
model is a representation of some domain or situation that supports understanding, reasoning, and
prediction” (Markman & Gentner, 2001, p. 228). The representation is formed through the
interactions of two components: structured information (e.g., trees or schema) and processes that
operate on the information (Merrill, 2000, 2001). The combination of information and processes
imbue mental models with great expressive power. Johnson-Laird (1983) asserts that they are the
basis for mentally representing “objects, states of affairs, sequences of events, the way the world
is, and the social and psychological actions of daily life” (p. 397), and further that they are
fundamental to human understanding: “all our knowledge of the world depends on our ability to
construct mental models of it” (p. 402).

Although Johnson-Laird’s final claim seems exaggerated, it has experimental support. In an
experiment with himself as the subject, Stratton (1896, 1897a, 1897b) recorded the effects of
wearing lenses that inverted his vision. He experienced vertigo during the first days of the
experiment and had difficulty coordinating actions such as walking or reaching for objects.
Understandably, “The entire scene appeared upside down” (1897a, p. 343). He also noted that he
retained a pre-experimental mental image of the world, to which he had to refer to walk, write, or
reach for objects. Eventually, however, he was able to anticipate where his arms and legs would
enter into his field of view and to coordinate their motion to comfortably accomplish these tasks. By
the eighth and final day, he noted that while stationary, the pre-experimental orientation dominated,
but while active and while keeping his arms and legs in view, “the general experience was
harmonious, and everything was right side up‖ (1897b, p. 469). His report describes the evolution of a mental model of his surroundings based on his experiences.

Knowledge structuring or chunking explains a well-known “catch-twenty-two” of learning, “In educational psychology, study after study showed that students’ ability to understand texts, to solve mathematical problems, or to learn new concepts in the social or natural sciences depended heavily on what the students already knew” (Greeno, Collins, & Resnick, 1996, p. 19). When embarking on a new course of study, learners have little structure into which they can add new information and must simultaneously acquire the information and develop a structure in which it can be organized. Alternatively, while studying a familiar topic, learners have established knowledge structures into which the new information is more easily added. Today, it is generally accepted “that experts possess hierarchically organized, integrated knowledge structures . . . . [while] the typical novice’s knowledge is accessed in a somewhat sequential fashion” (Mestre, Dufresne, Gerace, & Hardiman, 1993, p. 304).

One of the many advantages of mental models is their ability to “provide a kind of simulation of events rather than descriptions of events” (Greeno et al., 1996, p. 18). For example, the ideal gas law summarizes the relation between pressure, volume, and temperature of an ideal gas as PV/T = nR, where nR is a constant in a closed system. This equation provides a complete and accurate but static description of the law. Without a deeper understanding of the law, learners can do little more than memorize the equation. A complete mental model of the combined gas law must subsume the equation but must also include dynamic features that allow the knower to manipulate or to mentally simulate the change of one quantity and witness the concomitant change to the other quantities. The dynamic features may be rooted in the knower’s past experience—witnessing an inflated balloon shrink in a refrigerator or watching the pressure rise in a cooker as it heats—or may be created through guided imagination. The simulation process adds meaning to the equation, which makes the equation more memorable and allows the knower to reconstruct it by arranging the variables so that they reflect the simulated behavior. More generally, mental models mimic whatever they model by mapping key features of reality to elements of the model, and by depicting real-world behavior through dynamic processes.

There are many advantages to understanding that information must be highly structured before it rises to the level of knowledge. First, it suggests that knowledge is constructed by continuous, ongoing processes rather than springing whole in a moment of insight. Indeed, Gibbons (1998/2001) notes, “Among the generally agreed properties of mental models or schemata is their plasticity, their extensibility, their forgetability, their interference on occasion with one another, [and] their ability to be learned. . . .” (p. 520). Second, it explains why “cramming” and memorizing are not effective learning techniques—they produce flat, unconnected memory structures that are unsuitable for problem solving and are quickly forgotten. Third, it explains why disorganized, ill-prepared instruction is ineffective—it typically fails to convey a sense of structure. Most importantly, knowledge structuring suggests effective learning and teaching strategies.

ASSUMPTION 2: LEARNING IS MEMORIZING

Language acquisition demonstrates the innate ability of most people to learn complex, abstract concepts. Nevertheless, many students, who are unschooled in the techniques of learning or who
equate knowledge with information, adopt memorization as their primary learning strategy, resulting in low-quality learning that is not effectively transferred to new problems. This does not imply that memorization does not play a role in learning. Many tasks require a certain “critical mass” of information such as specialized terminology or symbols (e.g., anatomical terminology or basic organic compounds) and many problems are more easily solved if some solution components are memorized (e.g., the times tables or the syntax of a for-loop). Furthermore, rote memorization or rehearsal is an appropriate approach when learning simple, basic facts (e.g., that “Pb” is the symbol for lead) or recurrent (i.e., rule-based or automated) constituent skills (van Merriënboer, 1997). However, the most effective memorization occurs during use, which contextualizes and automatically selects the information worth memorizing. By solving many problems that require multiplication or that require iteration in a computer program, learners naturally memorize the times tables or the syntax of a for-loop.

Memorization is also useful when learning a completely new concept—when the learner does not have a schema or mental model to help organize the new information. The problem arises when learning does not progress beyond memorization. Mayer (1999, 2001) notes three distinct learning outcomes: (a) no learning, (b) rote learning, and (c) meaningful, constructivist, or transfer learning. “The characteristic that distinguishes someone who learns by understanding from someone who learns by rote is the ability to engage in problem-solving transfer” (Mayer, 1999, p. 147). Learners who understand a concept are able to transfer that knowledge to new situations and to devise solutions to new problems.

The kind of learning that supports knowledge transference and problem solving develops highly structured knowledge organizations within the knower and implies a construction process. “Constructivist conceptions of learning . . . assume that knowledge is individually constructed and socially coconstructed by learners based on their interpretations of experiences in the world” (Jonassen, 1999, p. 217). Phillips (1995) notes that although “constructivism has many sects—each of which harbors some distrust of its rivals” (p. 5) that they all share an “emphasis . . . on the necessity for active participation by the learner” (p. 11). Active participation is manifest as three component learning activities: skill, metaskill, and will (Mayer, 1999, p. 147).

1. **Skill.** Learning is a skill composed of three sub-skills: selection, organization, and integration, which Mayer (1999) summarizes as the SOI model (pp. 148-151). This succinct model is not a detailed or comprehensive learning theory but is practical, easy to use, and can significantly increases learning effectiveness.
   a. **Selection.** While reading a text, attending a lecture, or engaging in other learning activities, students are presented with an overwhelming amount of information. Specifically, information may arrive more quickly than it can be processed from sensory memory to short term memory and from short term memory to long term memory. Although in some sense all information in a text or in a lecture is important, students must consciously differentiate and select the critical or key information. The role of the selected information is a function of a given knowledge representation: For meaningful learning it is the subsumption or anchoring points, it corresponds to the labels at each non-leaf node of a tree, and for schema or mental models it is the keys the knower uses to access or recall the associated schema or model. Students may not have sufficient domain experience to
select appropriate key information and so teachers should guide the selection, which implies that students must be aware of the guiding and of the overall organizational process. Furthermore, students are unlikely to understand all of the information at once, so the selected information also acts as a future study guide.

b. **Organization.** If knowledge can be viewed as a mental model, then it follows that “learning can be viewed as a process of model building” (Mayer, 2001, p. 51). This “process of model building” constitutes Brown & Duguid’s “digestion” process that characterizes knowledge and sets it apart from mere information. The contemporary view “that understanding is gained by an active process of construction rather than by passive assimilation of information or rote memorization” (Greeno et al., 1996, p. 22) recognizes two critical aspects of learning: first, that learners must individually construct their own knowledge; and second, that the construction process is an active one. Organization is a continuous process in which learners rearrange and connect information to create increasingly structured knowledge.

c. **Integration.** Simon (1998) maintains that it takes ten years to develop domain expertise. This stance is consistent with the observation that experts’ knowledge is more highly organized and integrated than novices’ knowledge. That is, knowledge is constructed from information and then is organized and integrated into expert knowledge over time. Selection, organization, and integration are active, conscious, and effortful processes. Additionally, organization and integration are protracted, iterative processes that complement each other, often take place concurrently, and span many learning events.

2. **Metaskill.** Metaskills are the “metacognitive and self-regulatory processes” (Mayer, 1999, p. 148) with which learners monitor their own understanding and guide their individual learning. Teachers and authors often punctuate instruction with, hopefully, thought-provoking questions; such questions illustrate the metacognitively-posed questions learners may use to gauge their understanding. For example, after reading a passage, learners may try to form an explanation of the passage. If successful, they continue; otherwise, they formulate a plan to better understand the text: reread the passage, read related material in the text or another book, write a question to ask in class, etc. Learners take responsibility for their own learning, and actively monitor and direct the process.

3. **Will.** Although important, skill and metaskill are subordinate to will or the “motivational and attitudinal aspects of learning” (Mayer, 1999, p. 148). Figure 2 illustrates how the three learning outcomes may be superimposed on a learning space defined by skill (including both learning skill and metaskill) as one axis and by will as the second, orthogonal axis. Recognizing that learning is “an active process of construction” (Greeno et al., 1996, p. 22) explains the relation between skill, will, and the learning outcomes. Only those learners who have developed appropriate learning skills and who are willing to actively participate in the learning process achieve meaningful or transfer learning. Committed learners who lack learning skills ultimately rely on memorization and rarely advance beyond rote learning. Finally, those with insufficient will fail to learn.
How learners study may reveal their dominant learning strategy (recognizing that their strategy may vary over time and between domains). Students that that focus on the momentary needs of an assignment by “skimming” for just the needed information or limit their study to “cramming” the night before an exam, accomplish little more than temporarily memorizing a few facts and procedures. They also typically use examples in a limited way, only “attending to the sequence of steps in solutions” (Greeno et al., 1996, p. 19).

Alternatively, successful learners generally engage in extended study during which information from multiple sources is integrated and organized with previous knowledge. Information from the text, lectures, assignments, and other sources are combined into a single, cohesive set of notes that reflect and parallel the learner’s construction of a mental model. While studying examples, they “elaborate what they read and construct explanations for themselves” (Greeno et al., 1996, p. 19). The process may vary between domains, but transfer learners generally ask themselves questions such as what does each part of the solution accomplish; why is each part included in the solution; are there other ways to solve the problem, and what are the advantages and disadvantages of each; upon which principles does the solution depend; at any point in the solution, what signals the next step and why; etc.?

Elaboration and explanation are vital learning skills, and remembering to employ them during learning is a vital metaskill. They guide the learning experience and initiate the knowledge construction process. Although students may develop these and other learning skills on their own, it is often only after years of ineffective and frustrating educational experiences. The constructivist view of knowing and learning adopted here “values knowing how to learn (and think and remember) as well what to learn (and think and remember)” (Mayer, 1999, p. 156). This view implies that it is appropriate, if not obligatory, to teach learning strategies in conjunction with content material. Coupled with thoughtful, principled instruction, learning skills can increase the effectiveness of a learning experience while lessening the frustration.

**Figure 2:** A learning space relating skill, will, and learning outcome.
ASSUMPTION 3: TEACHERS DISPENSE KNOWLEDGE TO STUDENTS

Failing to appreciate the difference between information and knowledge leads both students and teachers to thoughtlessly adopt a knowledge transfer view of learning and instruction. This view assumes that “knowledge can be transferred from teachers . . . and acquired by learners” (Jonassen, 1999, p. 217), which encourages students to play a passive role in the learning process. Reigeluth (1999) observes that, “Trainees and students alike are usually expected to sit down, be quiet, and do what they are told to do. Their learning is directed by the trainer or teacher” (p. 18). In this paradigm, a student may be sitting quietly, outwardly doing what he or she is told—and yet be disengaged and not learning. Such passive behavior is antithetical to the active nature of learning and knowledge construction proposed by the constructivist paradigm.

The knowledge transfer perspective casts teachers as the only active members in the teaching-learning partnership, which places a disproportionate amount of responsibility for learning on them. Constructivist views of teaching and learning demand a more balanced distribution of responsibilities, emphasizes the learner’s cognitive rather than behavioral activity, and places the responsibility for learning on the learner. It also clarifies the distinct and complementary roles that teachers and students play in the learning process:

Learning implies the existence of at least one intention, will or agency—the learner’s. Instruction implies the interaction of at least two—the learner’s and at least one other. . . . But learning is still principally within the control of the individual. Instruction, therefore, does not cause learning but supports those learning intentions to which the learner commits. (Gibbons, 1998/2001, pp. 512-513)

Balancing the responsibility for learning between the teacher and the student and clarifying their roles does not absolve the instructor of all responsibility. Mayer (1999) argues that if “learning depends on the learner’s cognitive activity rather than the learner’s behavioral activity [that] it follows that instructional design should seek to encourage the learner to be cognitively active” (pp.146-147). Merrill (2000) adds that “a major concern of instructional design is the representation and organization of subject matter content to facilitate learning” (p. 1). Viewing knowledge as a constructed structure suggests approaches for encouraging cognitive activity and for organizing subject matter to facilitate learning.

Observing that learners construct knowledge from their experiences, Jonassen (1999) suggests that “instruction should consist of experiences that facilitate knowledge construction” (p. 217). In contrast to the knowledge transfer view, learning from experience demands the learner’s active participation. However, that active participation must be earned with appealing, engaging, and relevant experiences based on informed instructional principles established by a combination of theory, research, and practice. Creating appropriate and effective learning experiences is a primary instructor responsibility.

The mental model view of knowledge further suggests how best to represent and to organize instructional material. If, as Johnson-Laird (1983) suggests, our understanding of the world is based on our mental models of it, then it follows that “discourse about the world must be model
 Assume a Spherical Cow: An Examination of Four Implicit Learning and Teaching Assumptions

Based” (p. 407). That is, if learning is centered on model construction, then instruction should also center on models. This perspective is precisely Gibbons’ (1998/2001) theory of model-centered instruction (MCI), which maintains “that the most effective and efficient instruction takes place through experiencing realia or models in the presence of a variety of instructional augmentations designed to facilitate learning from the experience” (p. 512). Learners engaged in MCI observe and explore the dynamic (cause-effect and time-space) and the static (whole-parts and kinds-of) relations occurring naturally in the problem domain. In harmony with the model view of knowledge and learning, the theory’s goal is “the establishment within the learner of internalized knowledge models. . . . [which] is accomplished by instructing from the basis of externalized models” (p. 514).

This conclusion implies that if learning is the effortful construction of knowledge, then teaching is the no less effortful construction of a message that supports knowledge building. This observation suggests two instructional techniques. First, learners often lack sufficient experience with new material to identify an appropriate knowledge structure. Instructors can help to develop that structure by creating an appropriate framework consisting of outlines or trees, and by highlighting and naming common attributes or schema fields. They can further help by deliberately identifying appropriate anchor points (i.e., by helping learners select critical information) during lectures, discussions, etc.

Second, if learning is the construction of mental models, then instructing is a process of representing, organizing, and presenting subject matter to facilitate and to improve the efficiency of that construction process. That is, the organization of the information presented in effective instruction should parallel the organization that learners must develop. If learners must identify the kinds-of, the whole-part, and the cause-effect relations existing in a problem domain and build a mental model that embodies and simulates those relations, then it follows that, instructors must also identify those relations and insure that they are adequately presented and exemplified. From this perspective, instructing and learning are complementary, model-centered activities.

Models provide a rich environment in which instructional experiences may unfold. However, learners may not be able to extract all available model detail in a single experience without aid. MCI anticipates this problem and includes a construct to provide that aid:

*Model-centered instruction prescribes that the vehicle for focusing attention on specific elements, states and patterns of behavior of a model is one or more carefully selected and sequenced problems that are within the learner’s ability to solve, defined with respect to the model. In order to solve the problems, the learner interacts with or manipulates the model physically or mentally until a solution to the problem becomes evident or possible. In the process, the learner creates new knowledge.* (Gibbons, 1998/2001, p. 526)

Learning and teaching are complementary activities carried out by equal partners. Problem-solving or transfer learning is most efficiently and effectively achieved with a balance of deliberate, principled instruction and motivated, skillful learning. Teachers must at all times draw on their experience, knowledge, and training to inform every aspect of instruction. Nevertheless, students bear the responsibility for their own learning, and their intentions, commitments, and goals outweigh other factors in determining the final learning outcome.
ASSUMPTION 4: LEARNING EQUALS GRADES AND DEGREES

Students expend a great deal of time, effort, and expense in school: their parents and others encourage them to get good grades and to earn a degree, and employers often hire based on certificates and degrees. Many assume that these external symbols necessarily correspond to learning or that they imply basic skills and the ability to learn, to solve problems, to preserve, etc. However, many problems arise when grades and degrees are the primary educational goal.

In both college and high school, students are all too well aware that their mission is to do whatever it takes to acquire a diploma, which they can cash in on what really matters—a good job. This assumption has the effect of reifying the formal markers of academic progress—grades, credits, and degrees—and encouraging students to focus their attention on accumulating these badges of merit for the exchange value they offer. That strategy means directing attention away from the substance of education, reducing student motivation to learn the knowledge and the skills that constitute the core of the educational curriculum. Under such conditions, it is quite rational, even if educationally destructive, for students to seek to acquire their badges of merit at a minimum academic cost, to gain the highest grade with a minimum amount of learning. (Labaree, 1997, p. 259)

There are many examples of the reduced motivation and devalued learning caused by focusing on “formal markers of academic progress.” Plagiarism is generally the first example cited: Running out of time to finish a project in a computer science course, a student takes code from a friend, makes superficial changes to it, and turns it in as his own, later claiming that his changes demonstrate that he understands the code and that, “I did my own work.” Fabricating data is a similar problem: Assigned to keep a “thought log” for a week, a psychology student whispers, “That takes too much time. Oh well, you just make it up anyway.” Where academic dishonesty is an undeniable problem, other examples may masquerade as more noble efforts.

Hard work and broad interests are valued personal characteristics. Nevertheless, overloaded schedules are a subtle but more common example of “credentialism”: A student, in an attempt to finish her degree quickly, enrolls in too many courses, and, when reminded of the outside study requirement, exclaims, “I could if this was my only class!” Similarly, a student involved in numerous extracurricular activities and working late, boasts that she only sleeps four hours per night—aside from causing her to fall asleep in class, sleep deprivation also decreases memory function and hinders learning (Tamaki, Matsuoka, Nittono, & Hori, 2008; Tucker, 2007; Tucker & Fishbein, 2008). Other examples lie between these two extremes.

Focusing on grades and degrees can lead students to set goals that limit their learning. When the goal is to make a specific, often minimal, grade, they expend little effort and achieve little learning beyond that goal: “I just need a C in this class,” or, “All I need is 73% on the final.” Most startling, however, is when a student completely disassociates a degree from learning. Labaree (1997) argues that this happens when students perceive that “a college degree has exchange value but not necessarily use-value; that is, it can be cashed in on a good job more or less independently of any learning” (p. 256): A student argues that a required course does not match his career plans but rejects the suggestion that a different department is better aligned with his interests, saying that he wants a computer science degree because it “has more prestige and pays better.”
The effect of credentialism on student goals is unfortunate given the impact that goals have on learning outcomes. Greeno et al. (1996) cite research focusing on and distinguishing between two kinds of goals that learners may pursue. Students who adopt performance goals desire to do or to perform well as judged by some external standard, while those who adopt learning goals desire to become intrinsically more capable. They conclude that students’ goals impact their self-efficacy and persistence, which then bears on the eventual learning outcome:

*Those students who believe that intelligence is a fixed trait (you are either smart or not in some area) tend to adopt performance goals, while those who believe that intelligence is acquired tend to adopt learning goals. If students pursue learning goals, they seek challenges and show high persistence in the face of difficulties. But if they adopt performance goals, they will only seek challenges and persist when they are confident of their ability to accomplish the task. Surprisingly, adoption of performance versus learning goals does not correlate with intelligence.* (p. 20, underline added)

Although intelligence is a factor in learning, it is not the sole or the chief determinant. Student’s goals play an equal or greater role, but those goals are not only a function of students’ attitudes and aspirations but also of their learning environment. Fifteen students responded to an anonymous survey about plagiarism, with several responses suggesting that the practice was widespread. One response stood out from the others: “I think students are justified in doing this.” Fortunately, other responses provided additional insight: “Some students (on occasion) feel they are taking a course that is ‘required’ and that they may never use the information in the future, so why should they care if they cheat their way to a passing grade.” And, “I think there are those students who do not wish to participate in a class because they feel they do not need the experience with whatever tool.”

Solving relevancy problems is a cooperative effort. Institutions must define a pertinent curriculum, void of unnecessary courses, that balance the breadth and depth necessary to create “capable citizenship and competent workers” (Labaree, 1997, p. 250). Students must choose a program of study for which the knowledge has meaning and value beyond leading to the “right” degree, must anticipate and seek a full and broad preparation covering the entire domain, and must accept the experienced judgment of the curriculum designers.

Furthermore, students and the educational community must cooperate over instructional time. Institutions bear the responsibility for establishing the curricular requirements such as credits and required courses. However, students also exercise control over instructional time by controlling the rate at which classes are taken, and the relative scheduling of classes, work, and personal activities. For their part, institutions must respond to these needs by providing support, and, whenever possible, flexible, accommodating schedules. But students also have an obligation to set and commit to honest learning goals and to establish effective strategies for reaching them. They must also establish realistic schedules that provide sufficient study and sleep time, negotiate obligations with employers, and plan for foreseeable family events.

Setting and striving for honest learning goals places a great responsibility on students and demands a high level of maturity of them. It is unreasonable to expect this level of maturity from
young students but it is reasonable to teach them a simplified notion of knowledge and the learning
skills needed to construct it. As students transition from compulsory to optional education, they
assume more responsibility for their learning, including the setting of honest learning goals.

CONCLUSION

The value of an assumption, either positive or negative, is measured by where it leads. This
discussion rests on the fundamental assumption that knowledge is a highly structured entity. Two
additional assumptions naturally follow: first, that learning is the conscious and effortful
construction of knowledge and second, that instruction is more efficient when it is organized to
support the construction process. Together, these assumptions benefit the educational process in
many ways.

Recognizing that the kind of knowledge needed to solve problems exists in a structured form
focuses the attention of students and teachers on the construction process. From the teacher’s
perspective, the focus suggests several steps for building better instruction: (a) identify the key or
anchoring information naturally occurring in the problem domain; (b) identify the static and dynamic
relations present in the problem domain; (c) organize the presentation of information to facilitate
the learners’ organization and integration of that information in their individual mental structures; (d)
create problems that focus the learners’ attention on important problem domain details; and (e)
create assessments that go beyond rote memorization and exercise learners’ deeper knowledge
structures.

From the student’s perspective, the focus explains the active nature of learning and the pivotal
roles of the student’s skills and goals. The focus also suggests several steps that learners may
take to improve learning effectiveness and efficiency: (a) skim assigned reading to identify key or
anchoring ideas—this strategy begins a framework for the knowledge structure; (b) while reading,
attending a lecture, etc., select additional key or anchoring ideas—this effort extends the
framework and forms a list of concepts for further, deeper study; (c) during subsequent study
sessions, add detailed information; (d) revisit the text and lecture notes often, integrating and
reorganizing the information to build more complete knowledge representations; (e) self-monitor
study and formulate plans for dealing with problems; (f) self-test understanding by explaining
concepts to yourself or to others; (g) pose questions to your mental models—“how do I ...” or “what
happens when ...”—clear and complete answers suggest that the model is correct and complete,
but vague, incomplete, or inconsistent answers or no answers at all highlight incomplete or
incorrect models; and (h) set valid and realistic learning goals.

The previous discussion describes four implicit assumptions: (a) knowledge equals information, (b)
learning is memorizing information, (c) teaching is dispensing knowledge to students, and (d)
learning equals earning good grades and degrees. The assumptions are often made by default, by
not defining knowledge, learning, and teaching, and by encouraging students to do well in school
rather than encouraging them to learn. When any of these four assumptions are made, they
impede learning and teaching. They are four spherical cows.

As teachers and students, we may continue to base teaching and learning on spherical cows, or,
as partners in the process, we can choose to make changes. Our first change must be to
permanently “put out to pasture” these four spherical cows. The consequence of our choice is summarized in the words of a forgotten philosopher: “If you keep doing what you’re doing, you’re going to keep getting what you’ve got.”

REFERENCES


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