Abstract: Skillful teachers have developed the ability to take learners from the first conception of a goal to its accomplishment in shorter and shorter periods of time, with fewer and fewer errors on the learners' part and with increasing satisfaction and diminishing frustration on the teacher's. This article deals with the extent to which teachers provide learners assistance in their struggles to accomplish goals. At times, teachers may provide more assistance than is actually required and, in so doing, inadvertently limit learners' development over the long term.

Keywords: learning, memory, practice, rehearsal, research, teaching

By Robert A. Duke

Their Own Best Teachers

How We Help and Hinder the Development of Learners’ Independence

I would imagine that all of us who chose to pursue careers in teaching made our decisions at least in part because we found great satisfaction in helping people, perhaps especially children. It’s a wonderful experience to teach your own child to catch a ball, to ride a bike, to read, and to engage in any number of other adventures associated with parenting through childhood and adolescence. We may not feel quite the same sense of connection with our students that we do with our own children, of course, but the nature of the feeling seems in many ways essentially the same. Young learners want to do things—to stand for the first time, to speak, to make a sound on a trumpet mouthpiece, to sing with a clear tone, to make a more beautiful ritardando—and we parents and teachers delight in our ability to help them accomplish what they set out to do.

As we become more skillful as teachers, we become more efficient at the task of helping, and we develop the ability to take learners from the first conception of a goal to its accomplishment in shorter and shorter periods, with less and less error on the learners’ part, and with increasing satisfaction and diminishing frustration on ours. This article is about that very aspect of teaching: the extent to which we as teachers provide learners assistance in...
their struggles to accomplish goals. In particular, it’s about the possibility that we at times provide more assistance than is actually required and, in so doing, inadvertently limit learners’ development over the long term.

**What Gets Remembered**

The current conception in psychology of what we think of as *now* (the psychological present) is an interval of about three seconds’ duration. Thus, a typical waking day may contain as many as 20,000 *nows*, most of which are entirely forgotten. And it’s a good thing that they are. There would be no advantage to my remembering every car I passed on the way to work in the morning, or to remembering the exact words that a coworker said in greeting me when I arrived at school. Those details are neither meaningful nor useful to me, and they are not worth my brain’s expending precious energy to store.

But some things that we experience are committed to memory, and some of our memories seem to us nearly indelible. This raises the question of what in our experiences and our perceptions of them signals the brain to hold on to a memory. What leads to a memory’s persistence?

Several semesters ago, I watched a video recording with one of my graduate students who was teaching a beginning cellist to play “Twinkle, Twinkle, Little Star” for the first time using his bow. Prior to each repetition, my student asked the young cellist to “get ready to play,” whereupon the child placed his bow at some wacky orthogonal angle to the string and smiled at his teacher. The teacher then moved the child’s bow to the correct position, reminded him to keep his bow straight, and directed him to begin playing, which he did. After the piece ended, my student gave some feedback, which the child listened to with careful attention, and again told the child to “get ready to play,” followed by the wacky angle of the bow on the string. The teacher dutifully moved the bow to the correct position, reminded the student of the importance of a straight bow, and the student played again. I watched this happen at least five or six times, after which I stopped the recording and looked at my student, who was clearly exasperated with her young charge. “What’s wrong with him?” she asked. “I keep putting the bow in the correct place, and he keeps placing it incorrectly.” Consider the sequence of events:

| Student places bow incorrectly |
| Teacher corrects position |
| Student plays |
| Teacher gives feedback and directs the student to begin again |
| Student places bow incorrectly |
| Teacher corrects position |
| Student plays |
| Teacher gives feedback and directs the student to begin again |
| Student places bow incorrectly |

... and so on.

The answer to my student’s question, “What’s wrong?” is that the student never placed his bow correctly on his own. Instead, he repeatedly placed his bow incorrectly and the teacher “fixed it.” This may seem like too obvious an example to be worth the trouble, but it effectively illustrates the central point of this article, namely, that the more teachers correct students’ errors, the less likely it is that those corrections will become a lasting part of students’ thinking and behavior. Students must have many opportunities to *identify and correct their own errors*, even though doing so requires more time than would be necessary if their teachers just did all of the correcting for them.

Herein lies one of the great impediments to teaching in a way that gives more time for students to think and figure out and try. *It feels slower* to the teachers who know they could more “efficiently” simply tell or show what needs to happen and get on with it. The problem with the “tell, show, and fix” strategy is that the learner’s brain is often not busy enough and working hard enough to actually create lasting change in the learner’s memory.

**Learning Is Error Correction**

It’s biologically expensive to change your mind. The old metaphor that brains are like tape recorders (or, now, flash drives) that our experiences are simply written on in real time is colorfully inaccurate. When you’re working at your computer and you decide to save your work and you click the Save command, your computer looks for a blank space on the drive, where it writes what you saved and assigns it an address. Binary switches on the drive flip from 0 to 1 or from 1 to 0 in ways that represent the stuff you saved. The next day, when you click on the file name, your computer simply finds the address and reads off the data attached to it. Barring some electrical malfunction or physical damage to the drive, what is read off is precisely what was written the day before.

Organic brains, including human brains, work nothing like that. First, there are no blank spaces in your brain. There’s a lot of stuff in there already, and what your brain tries to figure out as it forms a new memory is how your ongoing experience is related to what’s already in your head—the old stuff with which the new stuff will become associated.

Second, most memories take time to stabilize and become resistant to interference and forgetting, a process called memory consolidation. With the exception of experiences that are tagged with intense emotion—fear, especially—most memories for most experiences begin in a labile state and, over the course of subsequent hours and days, are susceptible to modification and fading. In the ensuing hours following a learning experience, the process of memory consolidation stabilizes memories, rendering them more persistent. Energy is required to accomplish this because memory consolidation involves changes to the physical structure of the brain. Unlike the hard drive, changes in memories stored in an organic brain require changes in the brain’s physical makeup and configuration. We now understand that the consolidation process continues during sleep, when memories of experiences during the waking day...
are further stabilized and, in some cases, enhanced. Finally, memories stored in organic brains are ever changing. Everything that we encounter, we perceive and remember somewhat differently than the person next to us, because each of us brings a different set of memories to the moment of shared experience. In other words, memories of the past, which create expectations about the future, influence our perceptions of the present.

How we experience each now is colored by what we've experienced previously, and our memory of a given now is susceptible to modification by what we experience in the future.

All of this is to say that human memory is not a static record of the past, like the memory of a computer's hard drive. Rather, it is dynamic, changing over time and as a result of experience. When your computer is working as it should, storing a new memory has no effect whatsoever on the other memories recorded on the drive. When your brain is working as it should, new experiences often influence the memories that have been stored in the past.

So what would motivate a brain to commit an experience to memory or to modify a memory that’s already stored? The answer is error correction. And by error, I mean a discrepancy between a learner’s intentions (expectations) and actual outcomes. In music, this definition of error extends well beyond wrong notes, wrong rhythms, or mushy diction and includes all of the discrepancies between what a musician intends and what a musician does. To an artist-performer, for example, a note that doesn’t start beautifully and a phrase ending that’s not timed quite right are errors (discrepancies between intention and outcome) in the same way that a missed key signature may seem like an error to a novice.

Learners’ attempts to resolve the dissonance between their expectations and subsequent outcomes create new memories and refine old ones. Being told or shown by a caring teacher how to correct the errors you make is not at all the same as resolving errors on your own, because the teacher can do much of the work for you: locate the error, explain its cause, and provide a prescription for eliminating it. Consider that in order to correct errors on your own, you first have to have an intention, then have to perceive the discrepancy between it and the outcome, and then have to change your behavior to eliminate it, most often over the course of multiple repetitions.

There are excellent models for this kind of advantageously error-filled learning that many of our students experience decorate.
all the time: well-designed video games. We have all known children who are declared intractably “unmotivated” by their teachers and parents, but who will sit in front of an Xbox until their thumbs bleed. What’s up with that? What’s up is that the game in the Xbox is a skillful, strategic, and highly consistent teacher. A great game leads players to develop expectations and intentions relevant to winning the game. Those expectations are often strategically thwarted by the game in ways that require modifications in the players’ thinking and doing. Over repeated attempts, players can shrink the discrepancy to near zero, at which point the game adds a new twist or a more challenging goal that in turn introduces new errors.

I often give a talk titled “Practice Makes Better. Practice Makes Worse. Practice Does Nothing at All.” I like the title because all three of those statements can be true, depending of course on what practice entails. For practice to make better, practicers need to perceive discrepancies between their intentions and the actual sounds coming out of their instruments or their own voices. And for that to happen, they need to actually have an intention about what sounds they are trying to make. I’ve met a lot of students who have no such intentions at all. Their intention is to make sound (off and on) for about thirty minutes, thus completing their practice requirement for beginning band or piano and getting a signature from their parents on their practice forms. I’ve met others for whom errors are only missed notes, missed rhythms, and stopping; they have little mental conception of the sounds they’re trying to produce or the ideas they wish to express to a listener through those sounds. None of these students will gain an optimal benefit from practice. They don’t have a clear auditory image in their minds of what they’re about to do (intention), so there is no way for them to assess the extent of the discrepancy between what they intend to sound like and what they actually sound like.

I think most music teachers subscribe to the idea that repetition is a necessary part of developing and refining music skills. So far, so good. But learners must be able to distinguish one repetition from another, and as they gain in physical skill, there must be commensurate gains in auditory and physical discrimination. Advising young students to play a given passage ten times, for example, is not fruitful if the students can’t hear or feel the difference between one repetition and the next. If they can’t, then it’s not surprising that practicing is viewed as generally unmotivating because, literally, it’s all the same to them.

Practicing an instrument or singing without clear expectations and intentions...
about what’s supposed to happen is like having to play a lousy video game for thirty minutes a day and have your parents sign an affidavit certifying that you did so. Imagine a video game with shapes on the screen that are so dark and obscure that you can’t really see what’s going on, and you’re not entirely sure what the shapes are supposed to do. You’re pushing buttons and shapes are moving around, but you can’t determine precisely what effect your movements are having on the dimly lit stuff on the screen, and you wouldn’t quite know what to make of it even if you could make it out. Wanna keep playing? No way.

Countless children practice music just like that. What they’re trying to accomplish is not entirely clear to them. They know that they’re supposed to repeat what they play, but they have little sense of how each of their repetitions differs from the others or how their physical movements moment to moment affect the sounds they’re making in each repetition. Wanna keep practicing trumpet? No way.

Well, why don’t these students know what they’re supposed to sound like? They’ve been told and they’ve been shown, and when they made mistakes in class or in their lessons, they were told and shown some more. They’ve had well-intentioned teachers correct their errors efficiently, consistently, and ultimately, unfortunately, in ways that limited their own cognitive involvement (and cognitive effort). Not good. Not enough (self-directed) error correction.

The Value of the Muddle

Perceiving a discrepancy between an intention and an outcome is often frustrating for a learner. It’s particularly frustrating when the path to resolving the discrepancy is not entirely clear and initial efforts do not lead quickly to discernible improvement. Confusion is a little unsettling. Not being able to do something you’re attempting to do is frustrating. How learners deal with the unsettled feeling and frustration has everything to do with how well they learn and how independent they become.

When our own children, after several attempts to reach a goal, become frustrated by some seemingly insurmountable obstacle, they often look to us for help, which we are often happy to provide. Many of our students behave similarly. I don’t know where to start. Tell me, I can’t figure this out. Explain it to me. I don’t know how to do this. Show me. One of my favorite graduate students told me about a student in her class who was trying to figure out a piano fingering as she was standing beside him watching. After several unsuccessful repetitions, he looked to her and said, “If you were a good teacher, you’d tell me how to do this,” whereasupon my very astute and skillful grad student replied, “Yes, but because I’m an excellent teacher, I’m going to wait a while longer while you figure it out.” Of course, she said that with the informed confidence that her student could in fact figure it out, which he did after the next few attempts.

Think about what the student learned from that experience, other than the fact that his teacher’s a hardnose. He discovered that be could figure it out. His moments in the muddle led to his arriving at an advantageous solution, and all of the errors he made along the way actually strengthened the memory of the solution and the path he took in reaching it. His memory for that fingering will in all likelihood be more persistent, more understandable, and more generalizable than it would have been if the teacher had simply told him what to do.

To understand how human learning functions best, it’s instructive to consider how very young children learn what they learn and to identify the features of their experiences. Consider an infant learning to ambulate. Kids want to move because they want to get somewhere, often with the goal of putting enticing objects into their mouths. All of us who’ve been around a lot of infants in car seats have enjoyed the sight of enormous smiles accompanied by flailing limbs at the sight of some wiggly, noisy toy. The smile reveals the toy’s appeal, and the flailing limbs reveal an inability to control the body to obtain a goal. As the weeks and months pass, children sitting upright on the floor learn that when they tip over in the direction of the object of their desire, the object is closer than it was when they were upright. After landing on their bellies, they learn in the ensuing days and weeks that by moving their arms and legs they can scoot a little closer still. After raising themselves up on hands and knees, they discover that there’s a combination of limb movements that will actually propel them in the direction they want to travel, eventually reaching the precious cat dish, which promptly goes in the mouth.

There are two features of learning experiences like this that are central to their effectiveness. First, the learning is highly goal directed (I can’t wait to find out what that cat dish tastes like!). Second, it’s fraught with error. Infants learning to move have very clear goals that they’re trying to accomplish, and on the way to accomplishing them, they fail a lot. Why does all that failure not lead to their just giving up and deciding that crawling and walking are not really worth it? Two things: the clarity of the goal and the fact that interposed among the many failures are many self-derived successes. Even to us adults, it’s nice when someone shows us how to do something we don’t know how to do. When we figure it out on our own, it’s downright spectacular.

If students’ learning comprises primarily doing things that teachers tell them to do and show them how to do, then it’s not surprising that many children find school unmotivating. What they’re learning is not really mathematics or science or musicianship. What they’re learning is to remember and follow teachers’ instructions. Compliance is a good thing in some ways, but it’s not exactly a path to creative, critical, independent thinking. It’s also an ineffective way to build flexible intellectual and physical skills that can be applied advantageously in situations that have not been explicitly taught. Doing that requires error on the part of learners—failing, figuring out what happened, trying again, failing some
more, figuring out some more, and finally getting it.

I was invited to give a talk at a meeting in Dallas, Texas, a couple of years ago, and one of the other people on the program was a famously successful young high-tech entrepreneur. During his talk, he described the workspace in one of his new Internet companies. Hanging on the wall was a large sign that read FAIL FAST. The message to his employees was not to avoid failure, but to hurry up and fail so you can gain more information about what you’re trying to do. How brilliant is that?

It’s next to impossible to learn anything deeply if you’re simply following instructions. Mistakes are essential in learning, but what renders the mistakes useful is their being corrected by the learner. It’s the repeated attempts in the face of failure that provide the most useful information, hone perception and skill, and develop insight into what the heck it is you’re trying to do. When you fail initially, and someone else does the fixing, you may in fact accomplish the goal you were attempting. But if you do the fixing yourself, you not only succeed; you also understand. And understanding is the key to intellectual and physical independence.

Doing what you’re told won’t get you all that, because it doesn’t sufficiently engage your brain. When you’re in the weeds and unhappy about it, having somebody guide you out is certainly a relief. Finding your own way out combines the feeling of relief with a feeling of intense personal satisfaction, gained as a result of increased understanding. Working through muddles, then, produces intellectual, physical, and emotional positives that are simply not attainable in any other way.

Structuring experiences like this requires much more than throwing kids in the weeds and wishing them luck. Creating unsolvable confusions for learners is just mean. But creating strategic confusions—estimating what learners are independently capable of and then designing tasks that require them to use their capabilities to reach meaningful goals—nurture the development of intellectual and physical skills while setting up personal rewards that are obtained through learners’ own efforts. Truly great teachers do this all the time. So do the authors of Angry Birds. And with some practice, and failure, and more practice, all teachers can learn to do this, too.

NOTES


7. The entrepreneur at the meeting was Scott Jones. Although I hadn’t heard of Jones before I met him in Dallas, he’d been affecting my life for a number of years. At age twenty-five, Jones sold his first company, a voice mail startup, for $843 million. Patented systems that Jones developed are used in voice mails all over the world. He went on to develop Gracenote, a name you may recognize because it’s emblazoned on the fronts of many CD players. He sold Gracenote to Sony for $260 million. He’s created a number of other companies as well. The employee workspace he told us about was located in what was at the time his newest venture, a company called ChaCha.