

# AN ESSAY ON THE ART AND SCIENCE OF TEACHING

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## Abstract

The primary purpose of this essay is to identify instructional practices that can serve to enhance teaching effectiveness. There is both an art and a science dimension to effective teaching. The science dimension entails a comprehensive knowledge of the discipline, both historical foundations and research on the frontiers. The art dimension, which is likely to be the more elusive of the two, involves presenting complex material to students in terms that are readily understandable. Organized around twelve principles, this essay delineates various techniques that may be employed to enhance overall teaching effectiveness, even among those individuals who may not be “natural teachers.” Selected lessons from Charles Franklin Kettering, one of America’s most prolific inventors, are integrated throughout the essay to bring these teaching principles to life. A secondary purpose of this essay is to offer a critical, albeit constructive, assessment of the teaching profession at the university level.

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## I. Introduction

This essay is the culmination of three decades of experience in teaching (“methods for effectively imparting information”) various groups, including university students, executives in Fortune 500 corporations, legislators and government regulators.<sup>1</sup> This experience provides a unique vantage point from which to make a number of observations about effective teaching at the university level and possibly beyond. I also trust this essay can help those in the teaching profession avoid the many obstacles they are likely to encounter along the way.

The primary purpose of this essay is to develop a set of principles for effective teaching. In organizing the essay in this manner, my objective is to delineate various practices and techniques that may be employed to enhance overall teaching effectiveness,

even among those individuals who may not be “natural teachers.” A secondary purpose of this essay is to provide an assessment of the teaching profession at the university level; and while this assessment is at times critical, I hope that it is also constructive.

I should begin with a word or two about my interest in the topic of this essay and how it came to be. In my first year of graduate school, I enrolled in a course on the Philosophy of Science taught by Professor David Hawkins. Professor Hawkins was no ordinary philosophy professor. He had earned his Ph.D. at Berkeley in probability theory where he became acquainted with Robert Oppenheimer, the renowned physicist who headed the Manhattan Project. Hawkins subsequently became an aide to Oppenheimer and the official government historian for that project (Lehmann-Haupt 2002). He published widely in an astonishing number of fields,

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including biology, mathematics, philosophy, political and social theory, economics and education and seemingly left a major mark in whatever field he happened to wander into on that particular day. He reserved his greatest passion for education and he devoted a significant part of his life to understanding how children think and learn (Hawkins 2002). He was the recipient of a MacArthur Foundation (“genius”) Grant in the very first year of the awards for work in philosophy and childhood science education. I can make no claim that this essay rivals any of Professor Hawkins’ writings, but he is the inspiration for it. He challenged his students to think seriously about teaching and how we can do it better.

Throughout this essay, I integrate selected lessons from Charles Franklin Kettering—one of America’s most prolific inventors and commentators on education and industrial progress. My purpose for highlighting Kettering’s teachings is four-fold. First, he struggled early on with his own formal education and managed to overcome handicaps that would have thwarted lesser men. Second, while he recognized the importance of formal education, he also understood its limitations in frustrating the process of learning and discovery. Third, Kettering fervently believed in the importance of *intelligent failure* as a learning tool, something we may have lost sight of in our educational system today (Boyd 1961).<sup>2</sup> For him, there was no disgrace in failure—there was only disgrace in not learning from failure. Finally, Kettering began his storybook career as a school-teacher and developed a reputation as a gifted and innovative teacher, one that paid close “attention to the individual needs of his students . . .” (Leslie 1983:6). He believed that teachers should endeavor to develop three qualities in their students: vision, imagination and courage.

Through *vision* they will see things as they really are. Through *imagination* they will dream greatly of things that may be. Through *courage* they will act boldly to make their dreams come true (Boyd 1961:30).

Charles Kettering (1876-1958) was born in the year the telephone was invented and died in the heart of this country’s industrial supremacy. His nearly 200 patents ranks second only to Thomas Edison. Among his inventions were the electric cash register, the individual ringing function for party line telephone service and the electric starter for the automo-

bile engine. Kettering began his career with National Cash Register, co-founded Delco Corporation and later served as the research chief at General Motors for over twenty-five years. While at GM he brought life to a struggling division known as Frigidaire by encouraging the development of Freon gas. Kettering was also a strong supporter of medical research. In 1945 he founded the Sloan-Kettering Cancer Institute. By any measure, Kettering’s life was one of greatness, genius and vision—of turning handicap into advantage.

Poor eyesight caused Kettering to drop out of Ohio University because he was unable to complete the drafting assignments for the engineering curriculum. He later succeeded in completing his degree at the age of twenty-seven by enlisting his college roommates to read the textbooks to him so he could learn the material and pass the examinations. Kettering’s poor eyesight was an impediment to him, but it also forced him to develop a keen intuition that served him well throughout his life and was a contributing factor to his success.

Perhaps due to his own educational experience, or his great success in spite of these difficulties, Kettering developed an inherent distrust for so-called experts and highly educated people. He believed that experts could be so caught up in what they already knew that they frequently had a difficult time learning anything else. As a result, they may be less likely to find an innovative solution to a difficult problem if it required them to think in a dimension different from that in which they were trained. As Kettering liked to point out, “The Wright brothers flew right through that smoke screen of impossibility” (Boyd 1961:239). He understood the importance of “thinking outside the box” long before it became part of the vernacular.

In a similar vein, it is noteworthy that two of the greatest mathematicians of the last century, John Nash and Srinivasa Ramanujan, were at times castigated by their colleagues for a less-than-complete familiarity with writings in their field.<sup>3</sup> An interesting conjecture is whether the creativity that so distinguished Nash and Ramanujan from other mathematicians was due, in part, to a type of *optimal ignorance* in which a somewhat incomplete knowledge of the discipline actually enhanced rather than inhibited their creativity.<sup>4,5</sup> This idea is closely related to Kettering’s observation that “experts” could be so encumbered by their vast knowledge that it made it difficult

for them to think in a dimension different from that in which they were trained.<sup>6</sup>

The remainder of this essay is organized as follows: Section II sets the stage for this essay with four key observations about the nature of the teaching profession, in Section III, twelve principles for effective teaching are developed and discussed in turn, and Section IV concludes.

## II. Key Observations

In writing this essay, I am motivated by four observations about the nature of the teaching profession and the individuals that make up its ranks. And, while I have not purposely set out to offend my colleagues in the academy, I recognize that the nature of the subject matter and the candor with which it is presented risks doing just that. My only hope is that I have not offended anyone who does not deserve to be offended.

First, individuals that embark upon a career in teaching at the K-12 level typically earn an undergraduate degree in education and serve a practicum in which their teaching skills are carefully evaluated. In contrast, a college professor normally earns a Ph.D. or some other terminal degree in their specialized research field and marches into the classroom to enlighten the masses with little or no credible demonstration of teaching competence.<sup>7</sup> This is paradoxical and, for all but the most naturally gifted teachers, wrongheaded. There is both an art and a science dimension to effective teaching. The science dimension is concerned with a comprehensive knowledge of the subject matter, including its historical foundations and research on the frontiers of the discipline. The art dimension, which is likely to be the more elusive of the two, is the ability to convey complex material in terms that are readily understandable to willing and sometimes unwilling students.

My second observation is that many (perhaps even most) professors do not teach particularly well and even those who do it well may not do it well for very long.<sup>8</sup> Universities often do little more than pay lip service to good teaching,<sup>9</sup> but virtually all of them value research scholarship and extramural funding.<sup>10</sup> Hence, in most cases the rewards from exceptional teaching must come from within.

My third observation is that the nature of the teaching profession lends itself to staying on longer

than you really should. A professor can always extend his lecture notes for one more year; the class time can be whittled away telling “war stories” or engaging in other mindless musings that lack any real focus. We should not delude ourselves into thinking that this is effective teaching because it is not. There are certainly outstanding teachers and in special cases teachers that are outstanding for long and distinguished careers. For myriad reasons, there are natural tendencies that make this the exception rather than the rule—not the least of which is the ever-increasing age differential between those doing the teaching and those being taught. What is more, delivering passionate and inspiring lectures is both physically and intellectually demanding—so even the very best teachers likely have only a limited number of truly extraordinary lectures in them. With few exceptions, teaching, or at least effective teaching, is a “young” person’s sport!

My final observation is that professors devote too much time teaching a given body of material and too little time developing their students’ ability to think.<sup>11</sup> Ideally, what we teach our students should serve as a floor on which they stand to reach greater heights rather than as a ceiling that limits what they are able to achieve. The classroom reality is often quite different, likely because the need to test our students in the end dictates what we teach them. As a result, we tend to emphasize mastery of material that is more amenable to objective evaluation. Creative thinking is the resultant collateral damage.

Most definitions of intelligence focus on the capacities that are important for success in school. Problem solving is recognized as a crucial component, but the ability to fashion a product – to write a symphony, execute a painting, stage a play, carry out an experiment – is not included, presumably because the aforementioned capacities cannot be probed adequately in short-answer tests (Gardner and Hatch 1989:5).

## III. Teaching Principles

The purpose of this section is to develop a comprehensive set of teaching principles and the rationale for them. The overarching theme is that effective teaching begins with first identifying and

then breaking down what can be quite formidable barriers to student learning.

**Teaching Principle 1.** Effective teaching strikes a delicate balance between the self confidence that students must develop to become independent thinkers and the humility they must maintain to recognize how much more they have to learn.

To impart information in the classroom most effectively and develop the students' self confidence, it is necessary for the teacher to subjugate his ego to some degree.<sup>12</sup> Spend less time convincing your students how smart you are and more time convincing your students how smart they are (or at least how smart they could be if they work hard and appreciate that there is always more to learn). The most effective teachers understand that their integrity in the classroom rests not only on what they know, but also on their willingness to concede what they do not know.

In this process, moreover, it is not so much the intellectual superiority of the teacher that counts as it is his maturity in facing the unknown and his willingness to leave unanswerable questions unanswered (Nouwen 1971:12).

In order to create the type of classroom environment conducive to learning, I begin the first class of each term with a quotation from the philosopher Ralph Waldo Emerson.

Meek young men grow up in libraries, believing it their duty to accept the views which Cicero, which Locke, which Bacon have given, forgetful that Cicero, Locke and Bacon were only young men in libraries when they wrote these books (Emerson 1971:56).

I then ask my students to tell me what this quotation means to them. The answers are always illuminating and serve as a catalyst for fruitful discussion. The motivation for the Emerson quotation is to convey to students the importance of trusting their own ideas and instincts,<sup>13</sup> while helping them to realize that their instincts can sometimes lead them astray.<sup>14</sup> As Emerson observed, "Books are the best of things well used; abused among the worst. . . . They are for nothing but to inspire" (Emerson 1971:56).

A professor must establish credibility with his students, but he must also create opportunities for his students to establish credibility with him. In a sense, he must enable his students to think even more highly of their ideas than those ideas might warrant on the merits. This can be done, in part, by example. As the eminent number theorist, G. H. Hardy, observed:

Good work is not done by 'humble' men. It is one of the first duties of a professor, for example, in any subject, to exaggerate a little both the importance of his subject and his own importance in it. A man who is always asking 'Is what I do worthwhile?' and 'Am I the right person to do it?' will always be ineffective himself and a discouragement to others. He must shut his eyes a little and think a little more of his subject and himself than they deserve (Hardy 1967:66).

The tension arises when Hardy's call for professors to "think a little more of his subject and himself than they deserve" morphs into professors thinking "a great deal more of his subject and himself than they deserve." This is problematic because an exaggerated sense of self-importance can be as off-putting as a modicum of well-placed self confidence can be inspiring.

The economist John Maynard Keynes emphasized that learning new ideas requires one to "escape from habitual modes of thought and expression" (Keynes 1935:viii). Joseph Schumpeter, another prominent economist and contemporary of Keynes, wrote of the *perennial gale of creative destruction*—the process of discovery in which new ideas and practices continually challenge and displace old ideas (Schumpeter 1942).<sup>15</sup> Learning is first and foremost a process of *creative destruction* that enables students to escape the habitual modes of thought and expression of which Keynes spoke. The more entrenched the knowledge, the more difficult the escape.

**Teaching Principle 2.** Effective teaching entails transmitting the subject matter on a number of different "frequencies" to accommodate the heterogeneous nature of how students learn.

The process by which students learn and process information is heterogeneous rather than

homogeneous—a natural outgrowth of the theory of multiple intelligences (Gardner 1983; Gardner and Hatch 1989). Hence, an effective teacher recognizes that the same teaching technique will not be successful with every student. The professor may be transmitting on a frequency different than that which some students in the class are receiving. As a result, it may be necessary for professors to broadcast on a number of different frequencies to ensure that each student in the class is receiving the information. In the face of obvious confusion about the material, simply repeating the same concept over and over again using the same technique (i.e., transmitting on only one frequency) or proclaiming the obvious nature of the material is not likely to be effective.<sup>16</sup>

Aristotle remarked that what is first in the order of intelligibility is often last in the order of learning. In the mind of a good teacher that dictum has the status of a truism. Through practical experience, such a teacher knows the diversity of such pathways of learning and is alert to discover new ones. In the mind of such a teacher the organization of subject matter is a network of multiple interconnections, not a single sequence of topical steps laid out in advance (Hawkins 2000:50–1).

For example, when I teach a particular economic concept, there are typically conceptual, graphical and mathematical methods by which to present the material. I generally employ all three methods, recognizing that not every student will understand each of the three approaches, but there is a very good chance that every student will be able to grasp at least one of the three approaches.<sup>17</sup> That is to say, while virtually every student “can get it” they cannot all get it in the same way.

Not surprisingly, most students are embarrassed to admit publicly that they do not understand a concept. For these students, it is critical that they have the opportunity to meet with professors one on one—ideally during office hours scheduled to maximize (not minimize) accessibility. When students come to the professor’s office, it is important that they feel welcome. One way to convey this sentiment is for the professor to get up from behind his desk and sit with the student at a table or some other common area. This reduces any anxiety that

the student may have about meeting with the professor and also signals a genuine desire to help on the part of the professor. When a professor sits on one side of the desk and the student sits on the other side, the desk itself becomes a barrier to learning. The teachers that have played the most significant role in my education have always been those that were the most accessible, those who literally and figuratively got out from behind their desks.

**Teaching Principle 3.** The effectiveness of the lecture is limited by the students’ willingness to “buy” what the teacher is “selling.”

Whether one is lecturing to students, business executives or government officials, it is important that each lecture begin and end with a concise statement of the significance of the particular issue for the “bottom line.” To wit, why should I want to know the answer to this question?<sup>18</sup> Whenever possible, the importance of the concept should be underscored with real-world examples so that your students become part of the subject matter rather than merely observers from afar. The Internet provides a virtually unlimited supply of such examples.<sup>19</sup> Effective teachers think carefully about how particular concepts relate to what students encounter in their everyday lives and build upon these relationships in the course of their lectures.

Charles Kettering confronted a similar problem when he set out to convince the paint engineer at GM that lacquer paint, which was dry to the touch in just a few minutes, could significantly reduce the time required to paint an automobile. Despite many attempts, Kettering failed to convince the paint engineer of the merits of this innovation. The paint engineer was simply “not buying” what Kettering was “selling.” Never one to be deterred, Kettering invited the paint engineer out to lunch and had his car painted while they dined. Upon his return from lunch, the paint engineer was unable to find his car. Kettering pointed to a car in the distance and inquired “is that not your car over there?” “My car is not that color” said the engineer, to which Kettering replied “it is now!” (Bernstein 1988:125-6).

Much like Kettering, effective teachers work tirelessly (and sometimes employ unconventional methods) to help students understand the relevance of the lectures and their value in addressing

real-world problems. As Keynes (1935:viii) astutely observed, “The difficulty lies, not in the new ideas, but in escaping from the old ones. . .”

**Teaching Principle 4.** The effective teacher never confuses indoctrination with teaching because the objective is to develop thinkers not “parrots.”

The classroom should not be used by professors as a platform to advance their own political or social viewpoints. A professor is most effective when s/he argues all sides of an issue in classroom discussions so as to encourage students to think carefully, objectively, and rigorously. It is often useful for the teacher to play the role of the devil’s advocate in facilitating classroom discussions. Most importantly, it is critical that students not feel obliged to answer examination questions in a certain way out of fear that the professor holds contrary viewpoints. A teacher is most effective when students cannot discern with any real certainty his personal political or social leanings. If a teacher can keep his students guessing, he can keep them learning.

**Teaching Principle 5.** The use of the *Soft Socratic Method* is superior to the traditional Socratic Method because teaching by facilitation is more effective than teaching by interrogation.

The *Socratic Method* can be an effective teaching tool,<sup>20</sup> but it need not be, and I believe should not be, used in a punitive manner.<sup>21</sup> The use of the *Soft Socratic Method* in which questions are posed to individual students, but there is no penalty *per se* if the question is answered incorrectly can be much more effective. It is counterproductive for professors to belittle students for providing incorrect answers. In fact, typically the professor need not even tell the student that s/he is incorrect because in many cases other students will jump in to provide the correct answer. The professor should stand ready to provide any clarification that may be required should the correct answer not be forthcoming. In this mode, the professor serves primarily as a facilitator (rather than an interrogator) in encouraging meaningful classroom discussion.

The professor can always interject a particular point or raise another question to keep the discussion moving in the right direction, but his role is more passive than active in nature. It is more

conducive for learning when students are corrected by other students rather than by the professor. The important point is not that the student fails *per se*, but that he learns to *fail intelligently*—in a manner that brings him one step closer to finding the solution. Moreover, even if the student provides an answer that is not correct, he likely made some statement in his response that was correct. The correct part of his answer should be underscored while the professor moves on to other students in the class who may be able to supply the correct answer in its entirety.

The *Soft Socratic Method* is most effective when professors take the time to learn some background information about their students. This may include photographs of your students along with a short biographical profile, including their major, class standing, graduate school plans and career aspirations. This enables the professor to reach out to students on a more personal level in applying the *Soft Socratic Method*.<sup>22</sup> For example, if a student is a computer science major, it may be helpful to seek her out should questions arise about the software battles between Apple and Microsoft. The fact that you have sought out particular students because of their expertise in a given field instills confidence in them and renders them more comfortable in answering questions in class. Once again, it is important for the professor to subjugate his ego, resist the urge to be all-knowing and make his students the stars of the lecture.

**Teaching Principle 6.** The effective teacher uses his research to enhance his teaching and his teaching to enhance his research while recognizing the importance of taking the long view.

A number of prominent economists report writing important papers in a particular field as a direct result of teaching a course in that field (Becker and Kennedy 2005, 2006). In this sense, there can be a complementary relationship between teaching and research.

Each lecture provides the teacher with an opportunity to sow the seeds of wisdom. Some of these seeds, though sometimes fewer than we would like, will find their way into fertile soil (what Hawkins (2002:18) refers to as the “subsoil of the human mind”) and the harvest that springs forth is likely to be intergenerational in nature. Whereas a professor may begrudge the high opportunity cost of

stellar teaching in terms of foregone research, this opportunity cost can be reduced significantly when proper account is taken of the research and accomplishments of the professor's students. Through effective teaching, the professor enables his students to scale intellectual heights that may even transcend the professor's own reach.<sup>23</sup> Hence, whether stellar teaching "costs" or "pays" depends upon how one measures the output over the long-term.

**Teaching Principle 7.** The dissemination of knowledge is maximized when the teacher develops multiple communication pathways and encourages interdisciplinary thinking.

It should not be presumed that just because professors are highly trained in a given field of study that they alone are capable of making a significant contribution to scholarship or industrial progress.<sup>24</sup> Charles Kettering underscored this point with his observation that some of the greatest inventions in history were the product of the work of non-specialists.<sup>25</sup> In 1940, at the Sesquicentennial of U.S. Patent Law, he made the following observation.

It is very difficult to tell just who is going to originate a new thing. A schoolteacher, Eli Whitney invented the cotton gin. Goodyear was a store clerk. Fulton and Morse were artists. The Wright brothers ran a bicycle shop and George Eastman was a bookkeeper. The developments that eventually made these men famous had practically no relationship to their occupations. But, of first importance each of them had an idea. And, with these men, the perfection of the idea became the controlling influence. (Boyd 1961:107).

To be a lifelong learner means that students learn from professors and professors learn from students in a manner that is bi-directional in nature.<sup>26</sup> This free exchange of ideas is essential to fostering a rich and productive learning environment.

It is likewise important for professors to understand that being an effective teacher means being an effective listener. It is all too easy to fall into the trap of thinking that we are teaching only when we are lecturing, but we are also teaching when we listen carefully to what our students have to say, whether they are responding to a question, asking

a question or simply making an observation. As Professor Maynard Mack (1998:176) observes:

From such interactions, rather than from the passive transmission of information, come those moments of revelation, however rare, that change lives.

It was not all that long ago that college professors taught a variety of courses across a number of disciplines. Largely as a result of the exponential growth in the academic literature in individual fields and subfields, these practices are no longer feasible. Unfortunately, the specialization in subfields of the discipline, a division of labor essential for cutting-edge research,<sup>27</sup> can work at cross-purposes with effective teaching and interdisciplinary thinking. Reading a book or an article in another field bears an increasingly high opportunity cost for professors actively engaged in research. Nonetheless, professors that read across disciplines, including subfields within their own discipline, and invest the time and effort to acquaint themselves with interesting problems in other fields will find themselves able to connect with students in a manner that those who are deeply but not broadly knowledgeable never will.

**Teaching Principle 8.** Effective teaching is less about providing students with the right answers and more about developing in them the ability to ask the right questions.

In an important sense, the art of asking the "right" question is more important than framing the "right" answer. There is a tendency for professors to want to provide all of the answers, perhaps to come across as all-knowing or to make their students feel comfortable. And yet, the real learning takes place when students are somewhat uncomfortable, when they are forced to struggle with the questions and put the pieces of the puzzle together for themselves.

All of which indicates how inadequate it is to think of the teacher as primarily someone giving out information to someone else who doesn't have it. The teacher's function is to help create the structure of the subject in the student's mind. That is why it is the teacher who asks most of the questions and not the

student. The student already knows a great deal more than he realizes he knows (Frye 1988:13).

Charles Kettering believed unfailingly in the importance of new ideas the genesis of which entailed asking the right questions. To underscore this point, Kettering was fond of telling a story about two chemists working on the so-called universal solvent in a small laboratory on the edge of town. One day a man driving by had a blow-out in one of his tires. Seeing the small laboratory in the distance, the man walked in and inquired of the two chemists working there if he might use their phone to call for assistance? “Sure” the chemists replied, “go right ahead.” The man picked up the phone and inquired of the chemists, “by the way, what are you working on so intensely?” The chemists replied with a sense of utter conviction, “we are working on the greatest invention in history—the universal solvent, a solvent that will dissolve anything.” “Very interesting” replied the man, “very interesting indeed, but what are you going to keep it in?” (Boyd 1961:108).

**Teaching Principle 9.** The effective teacher crafts his lectures to play to his strengths in communicating the material in the classroom, be it through humor, music, poetry, etc.

Student anxiety over the complexity of course material can be a formidable barrier to learning. Breaking down these barriers is the first order of business. The students in the classroom will not be at ease in learning the material if the teacher is not at ease in presenting the material. Hence, a *one-size-fits-all* approach to crafting lectures is not likely to be effective. I tend to interject humor into my lectures because I believe in the power of *learning-through-laughter*—a process by which humor reduces student anxiety, lowers barriers to learning and facilitates comprehension. I know of other professors that play musical instruments, sing and even play rock music to achieve similar results.

By the use of humor in the classroom, I do not mean to suggest that it is necessary for teachers to serve as the comedic equivalent of late-night talk show hosts. A little bit of humor can go a long way in refocusing students’ attention and keeping them interested in the material. Indeed, there is a beneficial leveling effect that can be achieved with the use of humor, particularly self-deprecating

humor, because it humanizes the professor in the eyes of the student. It is especially important to interject humor if the material is dry and it is difficult for students to maintain concentration for extended periods of time.<sup>28</sup>

**Teaching Principle 10.** The well-planned lecture like the general’s battle plan should be sufficiently flexible in design to allow for real-time adjustments necessary to address unforeseen obstacles encountered in the course of the “struggle.”

An effective lecture must be carefully prepared, but not over-prepared. The latter occurs when the lecture is so thoroughly scripted that it takes on a degree of rigidity (and often a humorless tone) that actually impedes learning. The effective teacher, through use of the *Soft Socratic Method*, is constantly taking the “temperature” of his class to assess whether the material is being received on the frequency on which it is transmitted. A professor that over-prepares his lecture may only grudgingly depart from the script to address issues that arise on a real-time basis. Students will quickly pick up on the professor’s reluctance to depart from his script and this works at cross-purposes with an interactive classroom environment.

Being well-prepared for a lecture means allowing for a certain degree of spontaneity in both the delivery of the material and in the responses to any questions that may arise. A good lecture is not a speech in which one merely reads the words off the proverbial teleprompter. A speech is rigid by design and broadcast by nature. In contrast, a classroom lecture is fluid by design and interactive by nature. A professor cannot anticipate the reactions of his students to every question that may arise, and this is precisely why attempts to script every word in advance are counter-productive.<sup>29</sup>

**Teaching Principle 11.** We fail our students when we teach them the material without also instructing them on the most effective methods to communicate what they have learned.

The unpleasant truth is that professors often refrain from assigning term papers or writing assignments because they do not want to go through the “agony” of reading them. Admittedly, there may be some pain involved, but it is necessary pain. In this age of e-mails, texting and tweeting,



our students' writing skills have been allowed to wane. We do our students a great disservice when we do not require them to develop these skills. Good writing skills are essential, not only for the communication of ideas but for nurturing creativity as well. Seasoned writers recognize that it is possible to write down ideas and thoughts that they were not even mindful that they knew. Such is the power of writing in unleashing the creativity from within.

Students should be encouraged at every turn to exercise economy of presentation, to formulate their arguments in a concise and effective manner so as to make "every word tell."<sup>30</sup> These principles apply to both in-class discussions and writing exercises.<sup>31</sup>

Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts. This requires not that the writer make all his sentences short, or that he avoid all detail and treat his subjects only in outline, but that every word tell (Strunk and White 1979:23).

It is likewise important for teachers to practice what they preach when it comes to communication of concepts. Professors increasingly rely upon PowerPoint slides,<sup>32</sup> transparencies and other media, frequently prepared by textbook publishers, to craft their lectures. Whereas, there can be important benefits from the use of these media there can also be significant costs.

For example, when writing on the board in the classroom, I observe that students are actively engaged with the material, transcribing their notes and carefully thinking about what they understand and what they do not. In contrast, the use of a PowerPoint format can be disengaging on two fronts. First, the professor is disconnected from his own lectures because the slides are frequently prepared by the textbook publisher. Second, the availability of the slides causes the students to put down their writing instruments and/or turn off their laptops—passively watching the learning process as opposed to actively participating in it. In this manner, PowerPoint-based lectures can marginalize professors by relegating them to passive projectionists rather than active lecturers.<sup>33</sup>

There is a beneficial learning process that takes place when students transcribe their own notes

rather than rely upon copies of professors' slides.<sup>34</sup> When students write down the material, they simultaneously write on the "hard drive" in their brains and this aids comprehension.<sup>35</sup> Students are seemingly able to identify points of confusion more readily when the material is created anew for them (i.e., written on the "board" in some fashion) rather than provided to them in pre-prepared format. Striking the right balance may take the form of providing students with electronic access to selected materials, but not at a level of granularity that reduces incentives to attend class and take careful notes.

**Teaching Principle 12.** The teachers' effectiveness is not measured by the numbers on the teaching evaluations at the end of the term, but by what they have helped their students to achieve over the course of a lifetime.

The available evidence indicates that high grades do not guarantee high teaching evaluations.<sup>36</sup> But even if it were possible to "buy" high teaching evaluations with high grades, the real question is why would you want to? I half-jokingly tell my students on the first day of class that I probably receive a \$1.50 more in compensation at the end of the year if I receive high teaching evaluations rather than average or low teaching evaluations, so the cost to adhering to my principles is negligible. My practice is to distribute the teaching evaluations from the last time I taught the course so that the students can read first-hand what former students had to say.

These practices give rise to two desired effects. First, those students that may be less serious about learning can find some other class in which to enroll.<sup>37,38</sup> Second, it is important for students to have full information about the course so that they can make an informed decision as to whether it is appropriate for them. In light of the high (and increasing) cost of a college education, every effort should be made to help students allocate their tuition dollars in the most efficient manner possible.

Finally, a word or two about teaching awards is in order. Whereas many gifted (and no so gifted) professors will receive a teaching award or two in the course of their careers, there are professors most deserving of such honors that will never receive them.<sup>39</sup> Some of the most influential and able professors that I encountered in college never even came close to winning a teaching award. I would not say that this was a badge of honor for

these professors, but I believe they understood what really mattered.

## IV. Conclusion

In his retirement years, Charles Kettering lectured throughout the country on industrial progress and research. He talked increasingly of failure—he was for it. Kettering had long been critical of the American educational system because he said it taught young people only the dark side of failure. He believed that failure was integral to effective learning and that preconception was the real enemy. He often said that if he could teach a young person to fail intelligently, he could make an inventor out of him. Indeed, for Kettering, an inventor was someone who did not take his education too seriously. I believe that what he meant by this is that the successful inventor leverages his centrifugal (“center-fleeing”) thought processes to move beyond the limits of his formal education rather than allow himself to be encumbered by it.

By definition, a professor plays a critical role in the education of his students, but that role is much more conductor than composer. The students’ formal education is but one part of a much larger and ongoing process of learning and discovery. The most important skills we teach our students are not reflected in a set of facts and theories, but in the ability to think rigorously, critically and objectively in the pursuit of truth and knowledge. Endowing our students with the thirst for such knowledge, the courage to challenge prevailing orthodoxy and the ability to ask the “right” questions transcends the importance of the subject matter itself.

So what is effective teaching? A precise definition of effective teaching is elusive, but we know it when we see it. Indeed, to truly experience effective teaching is, to paraphrase Ernest Hemmingway, “a moveable feast” because “wherever you go for the rest of your life, it stays with you . . .”<sup>40</sup> It is on this note that I would like to bring this essay to a close.

David Hawkins, my former philosophy professor, passed away in 2002 and it has been more than three decades since I walked out of his classroom for the last time. Through the years, I have come to appreciate that the real beauty of the Hawkins lectures is that they never stop teaching. That is, I suppose, the real magic of it all; the important

lessons, the ones we take with us and keep close to our heart never really die—they are passed along from one generation to the next as part of the sacred covenant of teaching.

## Notes

1. There are notable differences between teaching university students and teaching other groups. For example, university students tend to internalize any difficulties with comprehension—“what am I missing?” In contrast, executives and government officials tend to externalize any such difficulties—“why can’t you be more clear?”
2. The late Randy Pausch, professor of computer science at Carnegie-Mellon University, gave out what he called “The First Penguin Award.” This award was given to teams of students that took the biggest gamble in trying new ideas and technology, while failing to meet their stated goals. See Pausch (2008:148–9).
3. See Nasar (1994) and Hardy (1967). In the case of Ramanujan, this lack of familiarity was likely due to his being isolated from the major centers of learning. For John Nash, it was seemingly more deliberate.
4. Nasar (1994:12) makes the following observation about Nash’s creativity.

No one was more obsessed with originality, more disdainful of authority, or more jealous of his independence. As a young man he was surrounded by the high priests of twentieth-century science—Albert Einstein, John von Neumann, and Norbert Wiener—but he joined no school, became no one’s disciple, got along largely without guides or followers. In almost everything he did—from game theory to geometry—he thumbed his nose at the received wisdom, current fashions, established methods. . . . Nash acquired his knowledge of mathematics not mainly from studying what other mathematicians had discovered, but by rediscovering their truths for himself. . . . When he focused on some new puzzle, he saw dimensions that people who really knew the subject (he never did) initially dismissed as naive or wrong-headed. Even as a student, his

indifference to others' skepticism, doubt, and ridicule was awesome.

5. The quotation that "life is a blank slate on which experience writes" is most often attributed to the philosopher, John Locke. What Locke (1690:1) actually wrote appears in the following passage.

Let us then suppose the mind to be, as we say, white paper, void of all characters, without any ideas:—How comes it to be furnished? Whence comes it by that vast store which the busy and boundless fancy of man has painted on it with an almost endless variety? Whence has it all the materials of reason and knowledge? To this I answer, in one word, from EXPERIENCE. (footnote omitted)

The relevant question then for the purposes of our discussion is whether this "experience" provides a basis for solving the particular problem at hand, or merely muddies the "slate" and makes it more difficult to see the solution. The notion of optimal ignorance derives from the basic idea that some knowledge is good, but too much may be bad. The conjecture is that there are not only decreasing returns to knowledge after a certain point, but quite possibly negative returns when the metric of interest is creativity and problem solving. In other words, is it "difficult to teach an old dog new tricks" because there is too much written on his slate?

6. As Nasar (1994:12) observes, Nash's unique style of thinking coupled with the absence of preconception differentiated him from other mathematicians.

. . . Nash saw the vision first, constructing the laborious proofs long afterward. But even after he'd try to explain some astonishing result, the actual route he had taken remained a mystery to others who tried to follow his reasoning. Donald Newman, a mathematician who knew Nash at MIT in the 1950s, used to say about him that "everyone else would climb a peak by looking for a path somewhere on the mountain. Nash would climb another mountain altogether and

from that distant peak would shine a searchlight back onto the first peak." (footnote omitted)

7. This statement should not be construed to suggest that formal training in teaching methods for new Ph.D.s would necessarily yield more effective teaching. In the case of K-12 teachers, Staiger and Rockoff (2010) find little empirical evidence that teaching credentials are related to teaching effectiveness.
8. The Harvard business historian, Thomas McCraw, contends that "Almost all businesses, no matter how strong they seem to be at a given moment, ultimately fail — and almost always because they failed to innovate." (McCraw, (2007:495). A related observation applies to teachers and for similar reasons.
9. Becker (2000) contends that top-rated universities and prestigious colleges appear to be placing more emphasis on the importance of teaching scholarship, and that this has become a major part of personnel decisions. This may well signify a sea change on the part of university administrators toward teaching. For example, Sowell (1993:205–6) previously described the winning of teaching awards at prestigious universities as "the kiss of death" because it often preceded the denial of tenure.
10. I would be remiss if I did not point out that grants provide critical funding for the operation of universities and this, of course, includes teaching.
11. Some of my students ask me why the examinations include questions that require them to think beyond the material discussed in class. My response is always the same, "no employer will pay you to tell them what they already know."
12. The importance of this practice was underscored in one of my first Ph.D. classes. The class was taught by a distinguished professor who had that very year won a Nobel prize. A student in the class was on the losing side of a debate with this professor when, as a last act of desperation, he suggested that perhaps the professor did not fully understand the intellectual subtleties of the material. We were awe-struck by the professor's restraint when he remarked only that "perhaps I do not fully comprehend the point the author

- is making; I should read the material again.” This was an incredible demonstration of humility, particularly among members of the academy for whom such an occurrence might be considered something of a “black swan” (Taleb 2007). The issue in dispute is long-forgotten, but not the free exchange of ideas that flowed in that classroom following this event. The deeper lesson to be learned is that when you have the goods, in this case a Nobel Prize, there is no need to continually remind your students of your intellectual prowess—learning must always take center stage.
13. Schumacher (1977:1) articulates a similar idea when he notes that at some point in the course of his education and intellectual maturity, he “ceased to suspect the sanity of my perceptions and began, instead, to suspect the soundness of the maps.”
  14. As Keynes (1935:vii) observed in the preface to his most famous work, “It is astonishing what foolish things one can temporarily believe if one thinks too long alone . . .”
  15. Kuhn (1996:Chapters IX and X) discusses similar ideas in the context of paradigm shifts in politics and science.
  16. There is an old adage about a mathematics professor who writes down the proof of a theorem on the blackboard. The last line of the proof reads that “it is intuitively obvious that A follows from B.” Immediately upon completing the proof, the professor walks to the back of the room and begins pacing back and forth while he studies the blackboard intently without uttering a single word. Suddenly, the professor leaves the classroom altogether and walks down the hall to his office. The students sit in the classroom for twenty minutes before deciding to send a representative to the professor’s office. The designated student arrives at the professor’s office and observes him busily scribbling mathematical calculations at his desk. At long last, the professor returns to the classroom, and with a big smile on his face he jubilantly announces “I was right, it is intuitively obvious!”
  17. Research by Cohn et. al (2001, 2004) raises thought-provoking questions regarding the value of graphical analysis as a learning tool in principles of economics courses, particularly among certain race-gender groups.
  18. Laskin (1999:§3) underscores this very point with his observation that “We absorb and remember information best when we know why it is important and how it is relevant.”
  19. Becker (2000:111–2) underscores the need for professors to bring the headlines into the classroom to keep students engaged with the material.
  20. The Socratic Method is a process by which information is conveyed and learning is fostered through a process of questions and answers. It is commonly used in professional schools that employ the case study approach, such as business schools and law schools. See McCraw (1999) for an illuminating exposition of the use of the case study approach in teaching business history to Harvard MBA students.
  21. The traditional form of the Socratic Method was perhaps most vividly portrayed on film in the movie *The Paper Chase* (1973). In a classic scene (Scene 30), the much-feared Professor Kingsfield (John Houseman) calls upon Hart (Timothy Bottoms), a first-year law student, to answer a question. Hart states, in a dismissive tone, that he has nothing relevant to say and passes on answering the question. Professor Kingsley fumes at this response and summons Hart down to the lectern. He coldly admonishes him, “Mr. Hart, here is a dime, call your mother and tell her that there is serious doubt about your becoming a lawyer.” Upon being publicly rebuked in front of his classmates, Hart proceeds to walk out of the classroom, but stops midway, turns around and exclaims “you are a son of a bitch, Kingsfield.” Professor Kingsfield pauses for a moment and then exclaims “Mr. Hart, that is the most intelligent thing you’ve said today, you may take your seat.”
  22. It is important not to discount the importance of calling upon your students by their names. This can be challenging, but not insurmountable, in large classes. In large lecture classes, the instructor can review background information on six or seven students in advance and call upon these students in class on that particular day. This practice goes a long way toward establishing the rapport with students that is necessary for effective teaching.
  23. A related idea is underscored in one of the original episodes of *Star Trek* entitled “Tomorrow is Yesterday.” The Starship Enterprise operates

- under Star Fleet's prime directive—a policy of non-interference with respect to the natural timeline of a civilization's development. The Enterprise crew is faced with a moral dilemma when it contemplates whether a detained pilot from an earlier time period should be returned to earth with knowledge of the future? Mr. Spock, the Vulcan first officer, dispassionately observes that the pilot did not make a significant contribution to mankind, so there would be no violation of the prime directive in not returning him to earth. He subsequently retracts his statement when he looks into the future and sees that the pilot's yet unborn son will go on to head the first successful Earth-Saturn probe, a rather significant scientific advance. Hence, the pilot does play a material role in the timeline of his civilization through the achievements of his son. *Star Trek, The Original Series, Season 1, Episode 19, "Tomorrow is Yesterday,"* Original Air Date, January 26, 1967.
24. This is not to suggest that being too much smarter than your professors is not without risk. A case in point is that of Milton Babbitt, who wrote a path-breaking dissertation at Princeton in the 1940s that used advanced mathematics to analyze the 12-tone system. Babbitt's dissertation was rejected, in large part, because no one on the music faculty could understand it. This injustice was corrected some forty-six years later when Babbitt's dissertation was resurrected from Princeton's Archives and he was finally awarded the Ph.D. See Princeton University Press Release (1992).
  25. The basic idea of tradable property rights for the management of environmental quality, the foundational idea for the *cap-and-trade* policies currently being debated, was actually conceived by a political scientist rather than an economist. See Dales (1968) and Baumol and Oates (1988). An English monk, Roger Bacon, invented gunpowder and in the process changed the entire course of civilization.
  26. Hawkins (2000:45–6) is critical of the fact that there is very little two-way interchange in schools. "What is found mostly is unidirectional flow, a truncated communication of 'instruction' punctuated by fixed alternative responses." And yet, "the desired outcome is that full symmetry be established, and learners turn into teachers."
  27. For example, the last mathematician for whom it could be said that he knew all of mathematics was Henri Poincaré (1854–1912). As noted by Eves (1976:433), "Mathematics has grown at such an incredible rate in modern times that it is believed quite impossible for anyone ever again to achieve such a distinction."
  28. McLuhan and Fiore (1967:10) underscore this idea in the following observation:
 

Learning, the educational process, has long been associated only with the glum. We speak of the "serious" student. Our time presents a unique opportunity for learning by means of humor—a perceptive or incisive joke can be more meaningful than platitudes lying between two covers.
  29. Hawkins (2000:45) observes that fostering two-way communication between student and teacher is critical for effective learning "and not predictable in its outcome from a perusal of the teacher's notebook."
  30. It is noteworthy that the U.S. Supreme Court allots only thirty minutes for each side to present their case. This disciplines the parties to think as carefully about what they are going to say as how they are going to say it.
  31. See also Williams (1990) for a comprehensive treatment of the principles of clear and persuasive writing.
  32. For a thought-provoking critique of the use of PowerPoint to effectively convey information, see Edward R. Tufte, "The Cognitive Style of PowerPoint: Pitching Out Corrupts Within," Reprinted in Tufte (2006:156–185).
  33. Tufte (2006:161) argues that there is a fundamental inconsistency between the use of PowerPoint and the core ideas of teaching. He argues further that the PowerPoint style "tends to set up a dominance relationship between speaker and audience as the speaker makes power points with his hierarchical bullets to passive followers."
  34. Cohn et. al (1995:303) find that "instructors who distribute notes and insist that students refrain from taking notes so that they can pay more attention to the lecture may be deceiving themselves."
  35. This suggests something akin to McLuhan's (1964:Chapter 2) distinction between a hot

## References

- and cold medium. A hot medium allows little for the observer to fill in, and the opposite is true for a cold medium. "Any hot medium allows of less participation than a cool one, as a lecture makes for less participation than a seminar, and a book for less than dialogue" (p. 37). In this sense, we might think of a PowerPoint lecture as a hot medium and a traditional lecture combined with the *Soft Socratic Method* as a cold medium.
36. Research by Isely and Singh (2005) suggests that the relevant explanatory variable for teaching evaluations is the difference between the grades students expect and their cumulative grade point average rather than the absolute level of grades or expected grades.
  37. Babcock and Marks (2010) report that the average college student in the United States today puts in less than 60 percent of the study time per week compared to their counterparts in 1961 (14 hours versus 24 hours). The authors conclude that "The most plausible explanation for these findings . . . is that standards have fallen at post-secondary institutions in the United States" (p. 1).
  38. Research by Isely and Sing (2005) suggests that instructors in classes that draw a disproportionate number of top-performing students would tend to receive lower teaching evaluations, *ceteris paribus*. The rationale for this finding is that top students may tend to credit their own abilities and work ethic for their superior performance rather than the instructor.
  39. Notably, Carrell, and West (2010) report a negative correlation between the ratings that professors receive on student teaching evaluations and the performance of those students in higher-level classes. This implies that professors who encourage deeper learning are seemingly penalized for their efforts. This raises questions about the value of student evaluations of teaching performance as a measure of instructional quality.
  40. The full quotation, which appears on the opening page of Hemmingway's (1964) book with the inscription "to a friend, 1950" reads as follows: If you are lucky enough to have lived in Paris as a young man, then wherever you go for the rest of your life, it stays with you, for Paris is a moveable feast.
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