APPENDIX G:

FELDER AND KOLB ON LEARNING STYLES

The following represents varying ways in which this course might pedagogically address different learning styles, values, and experiences of a multicultural student body.

Kolb Learning Styles:
CE-Concrete Experience-Learning from specific experiences; relating to people; being sensitive to feelings and people.
AE-Active Experimentation-Learning by doing; showing ability to get things done; taking risks; influencing people and events through action.
AC-Abstract Conceptualization-Learning by thinking; logically analyzing ideas; planning systematically; acting on an intellectual understanding of a situation.
RO-Reflective Observation-Learning by reflecting; carefully observing before making judgments; viewing issues from different perspectives; looking for the meaning of things.

Felder’s Learning Styles:
Sensing Learner-Focus on sensory input; practical; observant; concrete (facts and data); repetition.
Intuitive Learner-Focus on subconscious; imaginative; look for meanings; abstract-theory and models; variety.
Visual Learner-Show me with pictures, diagrams, sketches, schematics, flow charts, plots, etc.
Verbal Learner-Explain it to me with spoken words and written words.
Active Learner-Process actively; think out loud; try “it” out; jump in prematurely; like group work.
Reflective Learner-Process introspectively; work quietly; think about “it;” delay starting; like solo or pair work.
Sequential Learner-Function with partial understanding; make steady progress; explain easily; analyze well; detail oriented.
Global Learner-Needs big picture; initially slow, then major leaps; can’t explain easily; synthesize well; systems thinking.
LEARNING STYLES (R.M. Felder)

Students preferentially take in and process information in different ways: by seeing and hearing, reflecting and acting, reasoning logically and intuitively, analyzing and visualizing, steadily and in fits and starts. Teaching methods also vary. Some instructors lecture, others demonstrate or lead students to self-discovery; some focus on principles and others on applications; some emphasize memory and others understanding.

When mismatches exist between learning styles of most students in a class and the teaching style of the professor, the students may become bored and inattentive in class, do poorly on tests, get discouraged about the courses, the curriculum, and themselves, and in some cases change to other curricula or drop out of school. Professors, confronted by low-test grades, unresponsive or hostile classes, poor attendance and dropouts, know something is not working. They may become overly critical of their students (making things even worse) or begin to wonder if they are in the right profession. Most seriously, society loses potentially excellent professionals.

I am developing a model of learning styles and a parallel model of teaching styles that seems to apply well to students in technical disciplines. (The model was originally formulated in collaboration with Dr. Linda K. Silverman, an educational psychologist.) The idea is not to teach each student exclusively according to his or her preferences, but rather to strive for a balance of instructional methods. If the balance is achieved, students will be taught partly in a manner they prefer, which leads to an increased comfort level and willingness to learn, and partly in a less preferred manner, which provides practice and feedback in ways of thinking and solving problems which they may not initially be comfortable with but which they will have to use to be fully effective professionals.

Assessment of learning style preferences

The Index of Learning Styles is a self-scoring questionnaire for assessing preferences on four dimensions of the Felder-Silverman model.

Publications related to learning styles

R.M. Felder, "Reaching the Second Tier: Learning and Teaching Styles in College Science Education," J. College Science Teaching, 23(5), 286-290 (1993). Defines the Felder-Silverman learning style model and identifies teaching practices that should meet the needs of students with the full spectrum of styles.

R.M. Felder, "Matters of Style," ASEE Prism, 6(4), 18-23 (December 1996). Principles and applications of four learning style models (Felder-Silverman, Kolb, and models based on the Myers-Briggs Type Indicator and the Herrmann Brain Dominance Instrument). The paper concludes that the choice of a model is almost irrelevant: teaching designed to address all dimensions on any of the models is likely to be effective, and all of the models lead to more or less the same instructional approach.


R.M. Felder and L.K. Silverman, "Learning and Teaching Styles in Engineering Education," Engineering Education, 78(7), 674 (1988). The original paper that defined the F-S learning style model. The "auditory" category in this paper was subsequently changed to "verbal," for reasons explained in Reference 1 and in greater detail in Reference 9.

The subsequent references focus on individual style dimensions, including several on the Myers-Briggs Type Indicator that are not included in the F-S model but are equally important in understanding different ways that students learn and perform in classroom settings.


R.M. Felder, "Meet Your Students: 3. Michelle, Rob, and Art." Chem. Eng. Education, 24(3), 130-131 (Summer 1990). Three different approaches to learning (deep, surface, and strategic), and the conditions that induce students to take a deep approach.


ACTIVE AND COOPERATIVE LEARNING (R.M. Felder)

In the traditional approach to college teaching, most class time is spent with the professor lecturing and the students watching and listening. The students work individually on assignments, and cooperation is discouraged.

Such teacher-centered instructional methods have repeatedly been found inferior to instruction that involves active learning, in which students solve problems, answer questions, formulate questions of their own, discuss, explain, debate, or brainstorm during class, and cooperative learning, in which students work in teams on problems and projects under conditions that assure both positive interdependence and individual accountability. This conclusion applies whether the assessment measure is short-term mastery, long-term retention, or depth of understanding of course material, acquisition of critical thinking or creative problem-solving skills, formation of positive attitudes toward the subject being taught, or level of confidence in knowledge or skills.

I have written or co-authored a number of papers about the use of active and cooperative instructional methods in college science and engineering courses, some reporting on my own classroom research studies and some summarizing the literature.


R.M. Felder and R. Brent, "Navigating The Bumpy Road to Student-Centered Instruction," *College Teaching, 44*(2), 43-47 (1996). The origins and patterns of student resistance to active and cooperative learning, and suggested ways to deal with the resistance.


R.M. Felder, "A Longitudinal Study of Engineering Student Performance and Retention. IV. Instructional Methods and Student Responses to Them." (1995). A detailed outline of an instructional approach that incorporates active and cooperative learning and a variety of other methods designed to address a broad spectrum of learning styles.


R.M. Felder, G.N. Felder, and E.J. Dietz, "A Longitudinal Study of Engineering Student Performance and Retention. V. Comparisons with Traditionally-Taught Students." (1998). Performance and attitude differences between students taught with the active/cooperative learning model described in the previous two references and students taught with a traditional instructor-centered model.


Methods and benefits of cooperative learning. (In Italian, with an English abstract).


**Active/cooperative learning web sites**

- [Ted Panitz's home page](#), A vast collection of resources on cooperative learning including an e-book, articles, faculty surveys, examples, and links to many other sites, compiled by Ted Panitz of Cape Cod Community College.

- [Innovations in SMET Education](#). The web site of the National Institute for Science Education at the University of Wisconsin. Resources on collaborative learning (including Cooper and Robinson's outstanding annotated bibliography on cooperative learning), learning through technology, and assessment of learning.

- [SMET Meta-Analysis](#). A meta-analysis of the effects on group work on student performance and attitudes compiled by Leonard Springer, Mary Elizabeth Stanne, and Samuel Donovan. Some of the most powerful existing evidence of the effectiveness of cooperative learning.

- [The University of Minnesota Cooperative Learning Center](#). Information and references on different aspects of cooperative learning, including "Cooperative Learning Methods: A Meta-Analysis," which summarizes the results of a large number of CL research studies. The site is maintained by David and Roger Johnson of the University of Minnesota.

- [Center for Cooperative Learning](#). A variety of resources related to cooperative learning, including lessons and activities. Maintained by Susan Ledlow, Arizona State University and Neil Davidson, University of Maryland.
OBJECTIVELY SPEAKING

Richard M. Felder
Rebecca Brent

Student A: "Buffo's first test is coming up in a week. I haven't had him before--can you just plug into formulas on his exams or does he make you do derivations and stuff?"

Student B: "It's tough to predict--last fall most of his questions were straight substitution but a couple of times he threw in things I never saw in the lectures."

Student C: "Yeah, and if you ask him what you're responsible for on the test he just gets mad and gives you a sermon on how bad your attitude is--we had a 600-page textbook and according to Buffo we were supposed to know everything in it."

Student A: "Forget that-no time. I'll just go through the homework problems and hope it's enough."

You can often hear conversations like that in the student lounge, and if you step across the hall to the faculty lounge you'll hear their counterparts.

Professor X: "All these students can do is memorize--give them a problem that makes them think a little and they're helpless."

Professor Y: "I don't know how most of them got past their first year. The average on my last test was 47 and some of them went to the department head to complain that I was testing them on things I never taught them, even though the chapter we just covered gives them everything they needed to know."

Professor Z: "It's this whole spoiled generation--they want the grades but don't want to work for them!"

Things are clearly not going quite the way either group would like. Many students believe that their primary task in a course is to guess what their professors want them to know, and if they guess wrong they resent the professors for being unreasonably demanding, tricky, or obscure. Professors then conclude that the students are unmotivated, lazy, or just plain dumb.

There is another way things can go. Suppose you give your students a detailed outline of the kinds of problems you would be calling on them to solve, including some that require real understanding, and then ask them to solve such problems on homework assignments and tests. Since you told them what you expected them to do and gave them practice in doing it, many or most of them will end up being able to do it--which is to say, they will have learned what you wanted them to know. Some professors might regard this process as "spoon-feeding" or "coddling." It is neither. It is successful teaching.

Instructional Objectives

An effective way to prepare students for the imminent possibility of having to think is by giving them instructional objectives, statements of specific observable actions that the students should be able to perform if they have mastered the course material. An instructional objective has one of the following stems:

- At the end of this [course, chapter, week, lecture], you should be able to ***
- To do well on the next exam, you should be able to ***

where *** is a phrase that begins with an action verb (e.g., list, calculate, estimate, describe, explain, predict, model, optimize,......). The more specific the task, the more likely it is that the students will learn to complete it.

Here are some examples of phrases that might follow the stem of an instructional objective, grouped in six categories according to the levels of thinking they require.

Knowledge (repeating from memory): list [the first ten alkanes]; identify [five key provisions of the Clean Air Act]; summarize [the procedure for calibrating a gas chromatograph].
Comprehension (demonstrating understanding of terms and concepts): explain [in your own words the concept of vapor pressure]; describe [how a flash evaporator separates components of a liquid mixture]; interpret [the output from an ASPEN flowsheet simulation].

Application (applying learned information to solve a problem): apply [the mechanical energy balance equation to estimate the pressure drop in a process line]; calculate [the probability that two sample means will differ by more than 5%]; solve [the compressibility factor equation of state for $P$, $T$, or $v$ from given values of the other two].

Analysis (breaking things down into their elements, formulating theoretical explanations or mathematical or logical models for observed phenomena): derive [Poiseuille's law for laminar Newtonian flow from a force balance]; explain [why we feel warm in 70°F air and cold in 70°F water]; classify [a problem solution in terms of the steps of Polya's problem-solving model].

Synthesis (creating something, combining elements in novel ways): formulate [a model-based alternative to the PID controller design presented in Wednesday's lecture]; design [an experiment to determine the effect of agitator speed on mixing efficiency in a stirred tank]; create [a homework problem involving material we covered in class this week].

Evaluation (choosing from among alternatives and justifying the choice using specified criteria): determine [which of the given heat exchanger configurations is better, and explain your reasoning]; optimize [the given methanol production process design]; select [from among available options for expanding production capacity, and justify your choice].

The six given categories are the levels of Bloom's Taxonomy of Educational Objectives [1]. The last three categories--synthesis, analysis, and evaluation--are often referred to as Bloom's higher level thinking skills.

Why Bother?

Well formulated instructional objectives are more than just an advance warning system for your students. They can help you to prepare your lecture and assignment schedules and to identify and possibly delete course material that the students can do little with but memorize and repeat. They also facilitate construction of in-class activities, out-of-class assignments, and tests: you simply ask the students to do what your objectives say they should be able to do. A set of objectives prepared by an experienced instructor can be invaluable to someone about to teach the course for the first time, and can help instructors of subsequent courses know what they should expect their students to have learned previously. If objectives are assembled for every course in a curriculum, a departmental review committee can easily identify both unwanted duplication and gaps in topical coverage, and the collected set makes a very impressive display for accreditation visitors.

Tips on Writing Objectives

- Try to write instructional objectives for every topic in every course you teach. Consider taking a gradual approach: formulating good objectives for a course may take some time, and there is no need to write them all in a single course offering.

- Include some objectives at the three highest levels of Bloom's Taxonomy. Analysis, synthesis, and evaluation questions can and should be included in every course, but they rarely show up in undergraduate courses. They are not that hard to write, but if you don't consciously set out to write some, you probably won't. Examples of higher-level questions are given by Felder [2] and by Brent and Felder [3].

- Avoid beginning an instructional objective with any of the four forbidden works: know, learn, appreciate, and understand. These may be the ultimate goals of instruction but they are not valid instructional objectives, since you cannot directly observe whether they have been achieved. Think of what you will ask the students to do to demonstrate their knowledge or understanding, and make those activities the instructional objectives for that topic.


- Formulating detailed instructional objectives for a course or even for a single topic in a course is not nearly as easy as simply listing the course topics in a syllabus. The effort is worthwhile, though. When we have
asked alumni of our teaching workshops which of the instructional methods we discussed they found most useful, instructional objectives ranked second only to cooperative learning. Many professors testified that once they formulated objectives for a course--sometimes one they had taught for years--they changed the course dramatically to one that was both more interesting and more challenging to the students and more enjoyable for them to teach.

References


At the teaching workshops we give, we propose a variety of instructional methods that deviate from traditional teaching practice. We recommend, for example, that instructors break up their lectures at frequent intervals with brief individual or small group exercises. We suggest using formal cooperative learning, in which students work on assignments in instructor-formed teams under conditions structured to assure individual accountability for all of the assigned material. We caution against giving tests that only the best students in the class have time to finish, and we argue strongly against curving grades.

Predictably, critical questions are raised about these recommendations and others we offer. In a series of columns beginning with this one, we review some of the most frequently asked questions (FAQs) and our responses. We have two reasons for doing this. First, the suggestions we offer at the workshops are far from unique with us: they are being made with increasing frequency by educational researchers, national study commissions, employers of engineering graduates, and accrediting bodies like ABET. If you have not already been exposed to them, you almost certainly will be before long, and some of our responses may be helpful as you consider the ideas being advanced. Our second objective is to offer those of you who are already using the new methods some answers to give your colleagues, administrators, and students, who are certain to raise the same questions with you.

Here, then, is our top ten list of questions frequently asked at teaching workshops.

- Is there any real evidence that these methods work?
- I have a lot of material to get through in a semester. Can I use these methods and still have time to cover my syllabus?
- I teach a class of 175 students in a fixed-seat auditorium. Will these methods work in large classes?
- I'm teaching a course by distance education. How can I get students active when I'm not in the same room with them?
- I tried putting students to work in groups, but some of them hated it and one complained to my department head. Why are some students so hostile to cooperative learning and what am I supposed to do about the hostility?
- Many of my students are (a) unmotivated, (b) self-centered, (c) apathetic, (d) lazy, (e) materialistic, (f) unprepared, (g) unable to do high school math, (h) unable to write, (i) unable to read, (j) spoiled rotten. (Pick any subset.) How can you teach people who don't have the right background or the willingness to work or even the desire to learn?
- Engineers constantly have to face deadlines. What's wrong with giving tests that only the best students have time to finish?
- What difference does it make if my test averages are in the 50s, since I'm going to curve in the end?
- My department head says that we can't count teaching too much in promotion and tenure decisions because we don't know how to evaluate teaching. Is there a meaningful way to evaluate teaching?
- The people who go to teaching workshops are mostly excellent teachers——the ones who most need to change wouldn't go to a teaching workshop at gunpoint. How can I persuade my traditional colleagues to do some of the nontraditional things you're recommending?

The workshop participants who ask these questions are doing what they have been trained to do as scientists and engineers and educated people, which is to ask for hard evidence before changing the way they've always done things. We applaud them for asking. In this column we'll offer an answer to the first question, and subsequent columns will deal with the others.

Q: Is there any REAL evidence that these nontraditional methods work?  
A: Tons of it.

Cognitive and educational scientists have learned a great deal about learning in recent years. The near-unanimous consensus is that we learn mainly by doing things and reflecting on the outcomes, taking in relatively little of what
we just see and hear (e.g., in lectures) and retaining even less. Countless studies have compared the academic performance and attitudes of students taught using active and cooperative methods with the performance and attitudes of students taught more traditionally. The evidence for the effectiveness of the nontraditional methods is overwhelming. (Specific references follow.)

Unfortunately, most professors have never seen a monograph, paper, or seminar on research into teaching and learning and would be hard-pressed to name a journal or conference where such research might show up. When the "Prove it!" card is played at our workshops (and even if it isn't), we therefore urge our questioners not to take our word for anything we say but to approach the matter scientifically and check the literature. We point them to a series of three papers in Chemical Engineering Education written by Jim Haile,¹ which collectively provide the best summary we've ever seen of what cognitive science has discovered about the learning process and the implications of this knowledge for teaching. We introduce them to the classic Teaching Tips,² in which Wilbert McKeachie offers an abundance of practical suggestions about every aspect of college teaching along with citations of the research that backs up the suggestions. We tell them about What Matters in College,³,⁴ Alexander Astin's monumental study of nearly 25,000 students at over 300 institutions that powerfully demonstrates the deficiencies of the traditional instructional model. We cite references on cooperative learning (e.g., Johnson, Johnson, and Smith⁵) that in turn cite hundreds of research studies attesting to the effectiveness of this approach, and we discuss the results of a longitudinal study one of us carried out of the effectiveness of cooperative learning in chemical engineering education.⁶,⁷ "Browse these references," we urge. "Then decide whether the research and the methods we're advocating are worthy of serious consideration."

More to come.

References


In a earlier column, we listed the top ten questions we get at teaching workshops and responded to the first one ("Is there any hard evidence that the instructional methods we recommend actually work?") In this column we consider two more questions.

Early in our workshops—usually within the first 15 minutes—we suggest that instructors include brief active exercises in their lectures. Some participants invariably express concern that they have to present a lot of material in their courses, and one of them poses Question #2: How can I take the time for those exercises and still cover the syllabus? Another follows up by observing that he or she teaches a lecture class to 175 students and raises Question #3: Can you use these methods in large classes?

Can you use active learning and still cover the syllabus?

A huge volume of material can be "covered" in a short period of time. If you put all of your lecture notes in PowerPoint or on transparencies and flash through them in class, you can get through several hundred pages of text in a month. The question is, what is your objective? If it is simply to present all of the prescribed course material, regardless of how much or little of it the students actually absorb, then you should not use active learning exercises—they do indeed slow things down. However, if the objective relates to what the students learn as opposed to what you present, then the goal should not be to cover the syllabus but to uncover the most important parts of it.

People acquire knowledge and develop skills only through repeated practice and feedback, not by watching and listening to someone else showing and telling them what to do. In lecture classes, most students are neither practicing nor receiving feedback on anything. They are just sitting there—sometimes watching and listening to the lecture, sometimes thinking of other things, sometimes daydreaming or sleeping. Most of them would learn just as much if the classes were cancelled and they were simply given the lecture notes and homework assignments and perhaps review sessions before the tests.

It’s a much different story if lectures are punctuated with brief active exercises that call on students—working individually or in small teams—to answer questions, begin problem solutions, fill in missing steps in derivations, brainstorm, formulate questions about material just presented, summarize, or do anything else that they may subsequently be asked to do in homework and on tests. The exercises energize the students (sometimes literally waking them up), direct their focus to the most important points in the lecture, and increase their subsequent concentration when the lecture continues. They give the students practice in the methods and skills the course is intended to teach them and immediate feedback on their efforts, thus meeting the criteria for learning to occur. Even if some material were dropped from the course syllabus to make way for the exercises, the increased learning would more than compensate for the loss.

But there is no need to shorten the syllabus. Suppose that instead of saying every word and writing every statement and drawing every diagram and deriving every equation in class, you were to put a lot of the material in class handouts that include gaps—skipped steps in derivations, axes with no curves showing—and exercises with spaces left for responses. "Estimate the solution of this problem." "If you increase the temperature, how would you expect the product yield to vary? Why?" "Draw the free-body diagram." "Fill in the missing steps between Eqs. (4) and (5)." "List three reasons why an experimentally determined value of this variable might differ from the one predicted by the formula just derived." Further suppose you announce that you will not go over most of the details in the handouts in class but any of it—especially the gaps and questions—could show up on the test. Most of the students will then actually read the handouts—at least after the first test, when they discover that you meant it.

This strategy accomplishes several things. By eliminating the need to say and write and draw everything in class, you buy yourself many classroom hours that can be devoted to the things that make learning happen—spending more time on conceptually difficult material, giving more examples, asking and answering questions, and implementing active learning. You can fill in some of the gaps in the handouts in class; get the students to fill in others in active learning exercises; and leave some for them to work out for themselves before the test. The students
learn more (we learn by doing, not by watching and listening), the classes are more lively, daily attendance increases, and the syllabus is safe.

Do active learning methods work in large classes?

Large classes (75 students or more) are a fact of life in the first year of engineering at most universities, and they are also common at higher levels at some institutions. Several references present ideas for making such classes effective.4-7

The larger the class, the more essential it is to use active learning. In a traditional lecture class with 15 students, it is not too difficult to get almost everyone actively involved in asking and answering questions and participating in discussions of course material. In a class with 40 students it is extremely difficult to do so, and in a class of 75 or more it is virtually impossible. Few students have the self-confidence to risk looking foolish by asking or answering questions in front of a large number of classmates, and the traditional pep talks proclaiming that there are no dumb questions and that wrong answers are also valuable generally have little effect. On the other hand, when a class is periodically given something to do in groups of two or three, the risk of embarrassment is minimal—the only real difference between a class of 20 and a class of 200 is that the latter class is noisier during activities.

A key to making active learning work in large classes is to stop the activity after the prescribed time interval and call on individual students or teams to state their results. (When we do this, we tend to overload on the back of the classroom, where many students go to avoid the instructor's attention. In our classes the students quickly learn that they can run but they can't hide!) If you only call for volunteers to provide responses after a group exercise, many students will not participate in the activity, knowing that sooner or later another student or the instructor will supply the answer. If they know that any of them could be called on, the same fear of embarrassment that keeps them from volunteering responses in the whole class will prompt most of them to work with the small group so that they will be ready with something if they are picked.

Instructors who have never used active learning in a large class usually envision two problems. They worry that some students will refuse to participate under any circumstances and that the noise level during the activity will make it difficult to regain control of the class.

In our experience, more than 90% of the students in a class routinely participate in active learning exercises after the first few, in which they feel awkward and unsure about what they are supposed to do, and the usual involvement is closer to 100%. Nevertheless, it disturbs instructors to see even one student sitting with arms crossed, pointedly refusing to participate, and the instructors often take such observations as evidence that the method is failing.

That's the wrong way to look at it. Suppose a full 10% of your students sit on their hands during an active learning exercise. This means that 90% of your students are engaged in thinking about what you want them to think about and trying to apply the concepts you have been teaching, so that the odds are 9 to 1 in your favor. In a typical traditional lecture, the percentage of the class actively engaged in thinking about the lecture content at any given time, let alone trying to apply it, is generally very low. Even if it is as high as 10%, which is unlikely, the odds are 9 to 1 against you. No instructional method—lecturing, active learning, multimedia tutorials, or anything else—is guaranteed to reach every student. As an instructor, the best you can do is go with the odds.

It is true that in a large class the noise level can make it more difficult to bring the students’ attention back to you, which makes it important to establish a signal (e.g. a buzzer, whistle, or handclap) for them to finish their sentence and stop the discussion. After the first few exercises, we have never had to wait for more than 10 seconds for the room to quiet down, even with 400 people there. Besides, if you are teaching a class in which the students are so involved in answering your questions or working out your problems that you have trouble getting them to stop, there are far worse problems you could have.

References


For theoretical and empirical support of this claim, see any text on cognitive psychology written in the last twenty years, e.g. M. Pressley and C.B. McCormick, Cognition, Teaching and Assessment, New York, HarperCollins, 1995.


"Teaching Large Class Sections," *The Penn State Teacher. II. Learning to Teach; Teaching to Learn*. 
<http://www.psu.edu/celt/PST/large.html>.
Definition of Kolb's Learning Style

Dr. Kolb devised his learning style inventory in the early 1970’s. It was based on Carl Jung’s Dialectic Tension, and Kurt Lewin’s Experimental Learning Theory.

The Kolb Learning Style Inventory test describes how you learn and how you deal with everyday situations. It does this by dividing the population into four unique groups.
It is concerned more with what a person is like, as opposed to reasoning and thinking skills.

The first Kolb Learning Style Inventory is Type 1 (concrete, reflective).
People who score highly in type one typically take in information through direct experience, or by doing something, acting it out, having a strong sense, or feeling about it, then taking the time to think it all over. The best way to teach someone of this nature would be to motivate the student, so they go out and do what they must to understand.

Next is Type 2 (abstract, reflective).
Those who score highly in type two tend to take in information best when observing or thinking about theory. If on a field trip, or in a lab, they would learn best, and enjoy the experience more if they were able to watch other do the task, while they take notes on the methods used. After observing, they need time to reflect on everything, therefore understanding it. This type of person learns best from experts, who know exactly what they're talking about, and can give the student examples of a theory.

Third is Type 3 (abstract, active)
The third type of person enjoys watching someone do something, or watching a video on how to do it, then immediately trying it themselves. This type is the type of person who reads manuals before assembling furniture or using a new electrical device. An excellent teacher for this type of person is one who acts as a coach, providing guidance and help along the way.

Lastly is Type 4 (concrete, active)
The final type of person according to David Kolb is one who, when presented with a new task, thinks back to a similar task they completed in the past, and tries the new one right away, moving according to their own experience. This type of person, in my opinion, would not read a manual for anything. When presented with a new ikea chair, for example, they would look at the parts, reflect on past experiences, and try to assemble it on the fly. The best kind of teacher for them is one who stays out of the students way, allowing them to bring their past experiences into the class, and letting them discover on their own.
My Kolb’s Learning Style Test Results

According to the online test I took, which can be viewed here, I scored slightly higher in reflective versus active, and am almost in the middle for concrete versus abstract in my learning.

Active versus Reflective
Although I did score slightly higher in reflective, this does not mean that I do not seek out opportunities to learn by actively doing something. Indeed, my marks are very close to one another.
My score for active versus reflective is below.

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As an example of reflective learning, if I was riding on a bicycle and the tires went flat, I would think about what could have caused it, and next time, based on my thinking, would avoid any activity which might again make them flat. An Active learner would likely try to see why their tires went flat by trying out different things they might have done to puncture them.

Concrete versus Abstract
I scored higher in concrete versus abstract learning, meaning I enjoy facts more than theories. However, because the difference between the two was slight (I was almost in the middle), I can still understand and put theories to use.
Below is an example of my score.

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This would suggest that I can write a report on abstract thoughts, such as this one on learning styles, but would rather stick to something I have concrete experience with, such as describing and analyzing the four "P's" in a marketing report.

Conclusion
If these two styles are put together, both concrete learning and reflective thought, it shows that I enjoy learning something which has a link to another subject I have learned before. And, when the material has been presented to me, I enjoy taking the time to think it all through, thus remembering it and understanding where it fits into my worldview.
Students have different learning styles—characteristic strengths and preferences in the ways they take in and process information. Some students tend to focus on facts, data, and algorithms; others are more comfortable with theories and mathematical models. Some respond strongly to visual forms of information, like pictures, diagrams, and schematics; others get more from verbal forms—written and spoken explanations. Some prefer to learn actively and interactively; others function more introspectively and individually.

Functioning effectively in any professional capacity, however, requires working well in all learning style modes. For example, competent engineers and scientists must be observant, methodical, and careful (characteristics of the sensing style in one of the learning style models to be described) as well as innovative, curious, and inclined to go beyond facts to interpretation and theory (characteristics of the intuitive style in that model). Similarly, they must develop both visual and verbal skills. Information routinely comes in both forms, and much of it will be lost to someone who cannot function well in both of these modes.

If professors teach exclusively in a manner that favors their students' less preferred learning style modes, the students' discomfort level may be great enough to interfere with their learning. On the other hand, if professors teach exclusively in their students' preferred modes, the students may not develop the mental dexterity they need to reach their potential for achievement in school and as professionals.

An objective of education should thus be to help students build their skills in both their preferred and less preferred modes of learning. Learning style models that categorize these modes provide good frameworks for designing instruction with the desired breadth. The goal is to make sure that the learning needs of students in each model category are met at least part of the time. This is referred to as "teaching around the cycle."

FOUR LEARNING STYLE MODELS

Before looking at some examples of teaching around the cycle, let's examine four learning style models that have been used effectively in engineering education.

The Myers-Briggs Type Indicator (MBTI)

This model classifies students according to their preferences on scales derived from psychologist Carl Jung's theory of psychological types. Students may be:

- extraverts (try things out, focus on the outer world of people) or introverts (think things through, focus on the inner world of ideas);
• **sensors** (practical, detail-oriented, focus on facts and procedures) or **intuitors** (imaginative, concept-oriented, focus on meanings and possibilities);

• **thinkers** (skeptical, tend to make decisions based on logic and rules) or **feelers** (appreciative, tend to make decisions based on personal and humanistic considerations);

• **judgers** (set and follow agendas, seek closure even with incomplete data) or **perceivers** (adapt to changing circumstances, resist closure to obtain more data).

The MBTI type preferences can be combined to form 16 different learning style types. For example, one student may be an ESTJ (extravert, sensor, thinker, perceiver) and another may be an INFJ (introvert, intuitor, feeler, judger).

Engineering professors usually orient their courses toward introverts (by presenting lectures and requiring individual assignments rather than emphasizing active class involvement and cooperative learning), intuitors (by focusing on engineering science rather than design and operations), thinkers (by stressing abstract analysis and neglecting interpersonal considerations), and judgers (by concentrating on following the syllabus and meeting assignment deadlines rather than on exploring ideas and solving problems creatively).

**Kolb's Learning Style Model**

This model classifies students as having a preference for 1) **concrete experience** or **abstract conceptualization** (how they take information in), and 2) **active experimentation** or **reflective observation** (how they internalize information). The four types of learners in this classification scheme are

• **Type 1** (concrete, reflective). A characteristic question of this learning type is "Why?" Type 1 learners respond well to explanations of how course material relates to their experience, their interests, and their future careers. To be effective with Type 1 students, the instructor should function as a *motivator*.

• **Type 2** (abstract, reflective). A characteristic question of this learning type is "What?" Type 2 learners respond to information presented in an organized, logical fashion and benefit if they have time for reflection. To be effective, the instructor should function as an *expert*.

• **Type 3** (abstract, active). A characteristic question of this learning type is "How?" Type 3 learners respond to having opportunities to work actively on well-defined tasks and to learn by trial-and-error in an environment that allows them to fail safely. To be effective, the instructor should function as a *coach*, providing guided practice and feedback.

• **Type 4** (concrete, active). A characteristic question of this learning type is "What if?" Type 4 learners like applying course material in new situations to solve real problems. To be effective, the instructor should stay out of the way, maximizing opportunities for the students to discover things for themselves.
Traditional engineering instruction focuses almost exclusively on formal presentation of material (lecturing), a style comfortable for only Type 2 learners. To reach all types of learners, a professor should explain the relevance of each new topic (Type 1), present the basic information and methods associated with the topic (Type 2), provide opportunities for practice in the methods (Type 3), and encourage exploration of applications (Type 4). The term "teaching around the cycle" was originally coined to describe this instructional approach.

**Herrmann Brain Dominance Instrument (HBDI)**

This method classifies students in terms of their relative preferences for thinking in four different modes based on the task-specialized functioning of the physical brain. The four modes or quadrants in this classification scheme are:

- **Quadrant A** (left brain, cerebral). Logical, analytical, quantitative, factual, critical;
- **Quadrant B** (left brain, limbic). Sequential, organized, planned, detailed, structured;
- **Quadrant C** (right brain, limbic). Emotional, interpersonal, sensory, kinesthetic, symbolic;
- **Quadrant D** (right brain, cerebral). Visual, holistic, innovative.

Engineering professors on the average are strongly Quadrant A dominant and would like their students to be that way as well, according to Edward and Monika Lumsdaine (see references). Most engineering instruction consequently focuses on left-brain Quadrant A analysis and Quadrant B methods and procedures associated with that analysis, neglecting important skills associated with quadrant C (teamwork, communications) and quadrant D (creative problem solving, systems thinking, synthesis, and design). This imbalance is a disservice to all students, but particularly to the 20-40% of entering engineering students with strong preferences for C and D quadrant thinking.

**Felder-Silverman Learning Style Model**

This model classifies students as:

- **sensing learners** (concrete, practical, oriented toward facts and procedures) or **intuitive learners** (conceptual, innovative, oriented toward theories and meanings);
- **visual learners** (prefer visual representations of presented material--pictures, diagrams, flow charts) or **verbal learners** (prefer written and spoken explanations);
- **inductive learners** (prefer presentations that proceed from the specific to the general) or **deductive learners** (prefer presentations that go from the general to the specific);
- **active learners** (learn by trying things out, working with others) or **reflective learners** (learn by thinking things through, working alone);
- **sequential learners** (linear, orderly, learn in small incremental steps) or **global learners** (holistic, systems thinkers, learn in large leaps).
For the past few decades, most engineering instruction has been heavily biased toward intuitive, verbal, deductive, reflective, and sequential learners. However, relatively few engineering students fall into all five of these categories. Thus most engineering students receive an education that is mismatched to their learning styles. This could hurt their performance and their attitudes toward their courses and toward engineering as a curriculum and career. In the section "Teaching to All Types" I suggest some instructional methods for addressing the learning needs of the full spectrum of learning styles.

LEARNING STYLES IN ACTION

Here are some ways that engineering educators have applied learning style models to provide students with an education that addresses both their learning strengths and weaknesses.

Applications of the Myers-Briggs Type Indicator

During the 1980s, thousands of engineering students and hundreds of engineering professors took the MBTI as part of a research study conducted by a consortium of eight engineering schools and the Center for Applications of Psychological Type. The study examined the effects of psychological type differences on the education and career development of engineering students. Educators have used the results to design methods for improved teaching and advising.

For example, Charles Yokomoto, an electrical engineering professor at Indiana University-Purdue University at Indianapolis, uses the MBTI as a diagnostic tool for students having academic difficulties. He administers the instrument to them, gives them the results, and describes the characteristics of their type. If the descriptions seem accurate to the students Yokomoto helps them devise remedial approaches that not only capitalize on their strengths but also use their weaker modes when doing so is the more appropriate learning approach. Letting the students assess the accuracy of the descriptions is essential. Like all other assessment instruments, the MBTI provides clues, not infallible labels. The student is the ultimate judge of his or her behavior patterns.

Working with an ISTJ (introvert, sensor, thinker, judger) student who was failing the introductory course in electrical circuits, Yokomoto speculated and confirmed that the student relied too heavily on memorization and drill (traits of ISTJs) as approaches to problem solving. The professor persuaded his student to add strategies based more on a fundamental understanding of the concepts. The student's performance began to improve: by his senior year he was earning A's, and he subsequently received a master's degree in electrical engineering.

In another case, Yokomoto found that an ENTJ (extrovert, intuitor, thinker, judger) student jumped directly into mathematical derivation on every homework and test problem (behavior consistent with extroverted intuition) rather than using routine procedures for routine problems. The resulting demands on the student's time caused problems with assignment completion and test performance. Once the student realized what he was doing, he began to apply his analytical talents when needed rather than using them indiscriminately and inefficiently. As a result, his performance improved.

(For more information about this work, contact Charles Yokomoto, yokomoto@tech.iupui.edu.)
Applications of the Kolb Model

Julie Sharp, an associate professor of technical communications in the chemical engineering department at Vanderbilt University, has administered the Kolb Learning Style Inventory to her technical communication classes and senior chemical engineering laboratory course for the past six years. In the communication class, she gives the students a handout describing ways to communicate effectively to the four different learning types. The students then prepare and give 10-minute presentations designed to appeal to all types. In the laboratory course, the students keep journals in which they describe conflicts and accomplishments within their lab groups, relating them to the group members’ learning styles. Sharp has found that teaching students about learning styles helps them learn the course material because they become aware of their thinking processes. More importantly, she says, it helps them develop interpersonal skills that are critical to success in any professional career.

(For more information, contact Julie Sharp, sharpje@vuse.vanderbilt.edu.)

In 1989 the College of Engineering and Technology at Brigham Young University initiated a faculty training program based on Kolb learning styles. About one-third of the engineering faculty members, all volunteers, were trained in the concepts of the Kolb model and methods of teaching to each Kolb type. The volunteers implemented the approach in their courses, reviewed videotapes of their teaching, and discussed their successes and problems in focus groups. The benefits of the program have been significant. Many faculty members—including some who did not participate in the original training—have redesigned their courses in an attempt to reach the full spectrum of learning styles. They do so by using a variety of teaching methods such as group problem solving, brainstorming activities, design projects, and writing exercises in addition to formal lecturing. Additionally, discussions about teaching have become a regular part of department faculty meetings; the general level of interest and concern about teaching has increased throughout the engineering college; and several faculty members have become involved in the “scholarship of teaching,” presenting and publishing peer-reviewed papers related to engineering education.

(For more information, contact John Harb, jharb@caedm.byu.edu, or Ronald Terry, ron_terry@byu.edu.)

Applications of the Herrmann Brain Dominance Instrument

In the early 1990s, Edward Lumsdaine and Jennifer Voitle, then of the University of Toledo's engineering college, studied the HBDI types of the college's students and faculty members. They found that many engineering students and professors were left-brain thinkers—logical, analytical, verbal, and sequential. Their data also indicated a strong attrition rate among right-brain thinkers, with many of them dropping out despite earning top grades in analytical courses. "A dominant reason for their choosing other majors is the inhospitable learning climate in engineering, which does not accommodate their thinking preferences, even though voices in industry are increasingly demanding engineers with precisely those thinking skills," Lumsdaine and Voitle claimed in a 1993 paper on their research.

The authors reviewed the existing mechanical engineering curriculum, found it skewed toward left-brained thinking skills, and set out to provide a better balance by introducing more creativity, design, innovation, and teamwork into selected courses. One course, "Introduction to Computing," originally consisted of 20 percent quadrant A activities (structured programming) and 80 percent quadrant B activities ("following the rules" in canned, routine programs). The redesigned version involved approximately 20 percent each for quadrants A and B and 30 percent each for quadrants C and D (student experiments, question formulation, design, modeling, and optimization). Students worked in teams formed by the professors to provide balance in HBDI types. Student
performance levels and attitudes to the course improved considerably because of these changes.

These results and results of similar studies led Edward and Monika Lumsdaine to conclude in a 1995 Journal of Engineering Education article that the HBDI can serve several important functions. These include helping students gain insight into their learning styles and formulate successful learning strategies; helping instructors understand students' questions, comments, and answers in the context of their thinking preferences; helping instructors and students form whole-brain teams for optimum problem solving; and assessing the influence of curriculum changes on individual and collective student thinking skills.

(For more information, contact Edward Lumsdaine, usfmdnan@ibmmail.com)

Applications of the Felder-Silverman Model

Along with Barbara Soloman, the coordinator for advising in the First-Year College at North Carolina State University, I am developing an Index of Learning Styles (ILS) that classifies students on four of the five Felder-Silverman dimensions (all but inductive/deductive). The ILS is in a beta version, and some professors are already testing it with their students.

For example, Peter Rosati, a civil engineering professor at the University of Western Ontario, has used the ILS to assess the learning styles of engineering faculty members and first-year and fourth-year engineering students at his university. Rosati found that faculty members were significantly more reflective, intuitive, and sequential than the students. The results suggest that professors could improve engineering instruction by increasing the use of methods oriented toward active learners (participatory activities, team projects), sensing learners (guided practice, real-world applications of fundamental material), and global learners (providing the big picture, showing connections to related material in other courses and to the students' experience).

(For more information, contact Peter Rosati, prosati@charon.engga.uwo.ca.)

At the University of Michigan, Susan Montgomery, an assistant professor of chemical engineering, is developing multimedia instructional modules that address the spectrum of Felder-Silverman preferences. To do this, she assessed her students' learning styles with the ILS and surveyed them to determine the attitudes of the different types toward different features of instructional modules. She reports that sensing and visual learners rated demonstrations highly; sensing learners liked having access to derivations of equations (which they may not have grasped as fully as the intuitors when the instructor first presented the equations in class); and active, sensing, and visual learners preferred movies more than their reflective, intuitive, and verbal counterparts did.

(For more information, contact Susan Montgomery, smontgom@engin.umich.edu.)

In another style-based approach to software instruction, Curtis Carver and Richard Howard, assistant professors at the U.S. Military Academy, have developed a hypermedia package for a computer science course on information systems. The package, which is distributed on the World Wide Web, is based on the Felder-Silverman model. Every lesson starts with a list of objectives and is followed by several different presentations of the lesson material, each geared toward a different learning style. For example, students can learn how to install a hard drive by going through a Harvard Graphics slide show, which is mostly text and appeals to verbal and sequential learners. Alternatively, they can learn the same thing by viewing embedded pictures, animations, and movies, which would appeal to visual and global learners.

The hypermedia package allows students to assess their learning styles using an online version of the ILS. The Web interface then provides them the option of having the material presented in a manner compatible with their style preferences, structuring the lesson so that the preferred media
elements come first. Students who prefer to organize the presentations themselves without following a particular sequence may do so also.  

(The hypermedia package can be accessed at http://www.eecs.usma.edu/cs383/tools.htm. For more information, contact Curtis Carver, carver@eecs1.eecs.usma.edu, or Richard Howard, howard@eecs1.eecs.usma.edu.)

At North Carolina State University, I've used the Felder-Silverman model to design the instruction in a longitudinal study of engineering education. I taught five sequential chemical engineering courses in a way that would appeal to a range of learning styles. I presented course material inductively, moving from facts and familiar phenomena to theories and mathematical models rather than always using the "fundamentals, then applications" approach. I used realistic examples of engineering processes to illustrate basic principles and occasionally provided opportunities for laboratory and plant visits. I stressed active learning experiences in class, reducing the time I spent lecturing. In homework assignments I routinely augmented traditional formula substitution problems with open-ended questions and problem formulation exercises. I used extensive cooperative learning, and tried to get the students to teach one another rather than rely on me exclusively. So far, the results of my study suggest that teaching to the full spectrum of learning styles improves students' learning, satisfaction with their instruction, and self-confidence.  

(For more information and references to papers on the longitudinal study, contact Richard Felder, felder@eos.ncsu.edu.)

TEACHING TO ALL TYPES

Here are some strategies to ensure that your courses present information that appeals to a range of learning styles. These suggestions are based on the Felder-Silverman model.

• Teach theoretical material by first presenting phenomena and problems that relate to the theory (sensing, inductive, global). For example, don't jump directly into free-body diagrams and force balances on the first day of a statics course. First describe problems associated with the design of buildings and bridges and artificial limbs, and perhaps give the students some of those problems and see how far they can go before they get all the tools for solving them.

• Balance conceptual information (intuitive) with concrete information (sensing). Intuitors favor conceptual information--theories, mathematical models, and material that emphasizes fundamental understanding. Sensors prefer concrete information such as descriptions of physical phenomena, results from real and simulated experiments, demonstrations, and problem-solving algorithms. For example, when covering concepts of vapor-liquid equilibria, explain Raoult's and Henry's Law calculations and nonideal solution behavior, but also explain how these concepts relate to barometric pressure and the manufacture of carbonated beverages.

• Make extensive use of sketches, plots, schematics, vector diagrams, computer graphics, and physical demonstrations (visual) in addition to oral and written explanations and derivations (verbal) in lectures and readings. For example, show flow charts of the reaction and transport processes that occur in particle accelerators, test tubes, and biological cells before presenting the relevant theories, and sketch or demonstrate the experiments used to validate the theories.

• To illustrate an abstract concept or problem-solving algorithm, use at least one numerical example (sensing) to supplement the usual algebraic example (intuitive). For example, when presenting Euler's method for numerical integration, instead of simply giving the formulas for successive steps, use the algorithm to integrate a simple function like y = x² and work out the
first few steps on the chalkboard with a hand calculator.

- **Use physical analogies and demonstrations to illustrate the magnitudes of calculated quantities** (sensing, global). For example, tell your students to think of 100 microns is about the thickness of a sheet of paper and to think of a mole as a very large dozen molecules. Have them pick up a 100 ml. bottle of water and a 100 ml. bottle of mercury before talking about density.

- **Occasionally give some experimental observations before presenting the general principle, and have the students (preferably working in groups) see how far they can get toward inferring the latter** (inductive). For example, rather than giving the students Ohm's or Kirchoff's Law up front and asking them to solve for an unknown, give them experimental voltage/current/resistance data for several circuits and let them try to figure out the laws for themselves.

- **Provide class time for students to think about the material being presented** (reflective) and for **active student participation** (active). Occasionally pause during a lecture to allow time for thinking and formulating questions. Assign "one-minute papers" near the end of a lecture period, having students write on index cards the lecture's most important point and the single most pressing unanswered question. Assign brief group problem-solving exercises in class that require students to work in groups of three or four.

- **Encourage or mandate cooperation on homework** (every style category). Hundreds of research studies show that students who participate in cooperative learning experiences tend to earn better grades, display more enthusiasm for their chosen field, and improve their chances for graduation in that field relative to their counterparts in more traditional competitive class settings.

- **Demonstrate the logical flow of individual course topics** (sequential), **but also point out connections between the current material and other relevant material in the same course, in other courses in the same discipline, in other disciplines, and in everyday experience** (global). For example, before discussing cell metabolism chemistry in detail, describe energy release by glucose oxidation and relate it to energy release by nuclear fission, electron orbit decay, waterfalls, and combustion in fireplaces, power plant boilers, and automobiles. Discuss where the energy comes from and where it goes in each of these processes and how cell metabolism differs. Then consider the photosynthetic origins of the energy stored in C-H bonds and the conditions under which the earth's supply of usable energy might run out.
CONCLUSION

A learning style model is useful if balancing instruction on each of the model dimensions meets the learning needs of essentially all students in a class. The four models I've discussed in this article satisfy this criterion. Which model educators choose is almost immaterial, since the instructional approaches that teach around the cycle for each of the models are essentially identical. Whether educators are designing a course or curriculum, writing a textbook, developing instructional software, forming cooperative learning teams, or helping students develop interpersonal, leadership, and communication skills, they will benefit from using any of these models as the basis of their efforts.

ADDITIONAL READING

For more information on each of the learning style models discussed in this article, check the following sources.

Myers-Briggs Type Indicator


Kolb Learning Style Model


Herrmann Brain Dominance Model


Felder-Silverman Learning Style Model


LEARNING-STYLE INVENTORY

David A. Kolb's Learning Style Inventory describes the way you learn and how you deal with ideas and day-to-day situations in your life. As this instrument is copyrighted please contact Jinny Flynn at (617) 425-4577 for licensing information.

David Kolb's learning cycle model (*Experiential Learning*, 1984), the learning style inventory, and associated terminology are based on the work of John Dewey, Kurt Lewin, Jean Piaget, and J. P. Guilford. For more information see the following materials:


LEARNING STYLES: A MULTIPLE INTELLIGENCES APPROACH

Multiple Intelligence (MI) theory states that there are at least seven different ways of learning anything, and therefore there are "seven intelligences": body/kinesthetic, interpersonal, intrapersonal, logical/mathematical, musical/rhythmic, verbal/linguistic and visual/spatial. In addition most all people have the ability to develop skills in each of the intelligences, and to learn through them. However, in education we have tended to emphasize two of "the ways of learning": logical/mathematical and verbal/linguistic.

Attached here are several sheets that describe the "seven intelligences". At the end is an inventory that can help you to see where you apply each of the intelligences, and to what extent. In addition to filling out this inventory, on a separate piece of paper, please describe the forms of learning/intelligence that you tend to utilize and/or enjoy most, as well as the forms which you feel you rarely utilize or have not spent much time developing. Please also comment specifically on your strengths and weaknesses relating to "interpersonal learning".

Much of this material is from: *Seven Ways of Knowing: Teaching for Multiple Intelligences* by David Lazear. 1991. IRI/Skylight Publishing, Inc. Palatine, IL.

**Body/Kinesthetic Intelligence**

This intelligence is related to physical movement and the knowing/wisdom of the body. Including the brain's motor cortex, which control bodily motion. Body/kinesthetic intelligence is awakened through physical movement such as in various sports, dance, and physical exercises as well as by the expression of oneself through the body, such as inventing, drama, body language, and creative/interpretive dance.

Capacities involved: --control of "voluntary" movements
--control of "preprogrammed" movements
--expanding awareness through the body
--the mind and body connection
--mimetic abilities
--improved body functioning

**Interpersonal Intelligence**
This intelligence operates primarily through person-to-person relationships and communication. Interpersonal intelligence is activated by person-to-person encounters in which such things as effective communication, working together with others for a common goal, and noticing distinctions among persons are necessary and important.

Capacities involved: --effective verbal/non-verbal communication
--sensitivity to other's moods, temperaments, motivations, and feelings
--working cooperatively in a group
--ability to discern other's underlying intentions and behavior
--"passing over" into the perspective of another
--creating and maintaining synergy

**Intra-personal Intelligence**
This intelligence relates to inner states of being, self-reflection, metacognition (i.e. thinking about thinking), and awareness of spiritual realities. Intra-personal intelligence is awakened when we are in situations that cause introspection and require knowledge of the internal aspects of the self, such as awareness of our feelings, thinking processes, self-reflection, and spirituality.

Capacities involved: --concentration of the mind
--mindfulness
--metacognition
--awareness and expression of different feelings
--transpersonal sense of the self
--higher-order thinking and reasoning

**Logical/Mathematical Intelligence**
Often called "scientific thinking," this intelligence deals with inductive and deductive thinking/reasoning, numbers, and the recognition of abstract patterns. Logical mathematical intelligence is activated in situations requiring problem solving or meeting a new challenge as well as situations requiring pattern discernment and recognition.

Capacities involved: --abstract pattern recognition
--inductive reasoning
--deductive reasoning
--discerning relationships & connections
--performing complex calculations
Musical/Rhythmic Intelligence
This intelligence is based on the recognition of tonal patterns, including various environmental sounds, and on a sensitivity to rhythm and beats. Musical/rhythmic intelligence is turned on by the resonance or vibrational effect of music and rhythm on the brain, including such things as the human voice, sounds from nature, musical instruments, percussion instruments, and other humanly produced sounds.

Capacities involved:
--appreciation for the structure of music
--schemes or frames in the mind for hearing music
--sensitivity to sounds
--recognition, creation, and reproduction of melody/rhythm
--sensing characteristic qualities of tone

Verbal/Linguistic Intelligence
This intelligence, which is related to words and language both written and spoken, dominates most Western educational systems. Verbal linguistic intelligence is awakened by the spoken word, by reading someone's ideas thoughts, or poetry, or by writing one's own ideas, thoughts, or poetry, as well as by various kinds of humor such as "plays on words," jokes, and "twists" of the language.

Capacities involved:
--understanding order & meaning of words
--convincing someone of a course of action
--explaining, teaching, and learning
--humor
--memory & recall
--"meta-linguistic" analysis

Visual/Spatial Intelligence
This intelligence, which relies on the sense of sight and being able to visualize an object, includes the ability to create internal mental images/pictures. Visual/spatial intelligence is triggered by presenting the mind with and/or creating unusual, delightful, and colorful designs, patterns, shapes, and pictures, and engaging in active imagination through such things as visualization guided imagery, and pretending exercises.

Capacities involved:
--active imagination
--forming mental images
--finding your way in space
--image manipulations
An MI Inventory for Adults
Check those statements that apply in each intelligence category. Use these intelligence categories to help you understand the types of intelligence you possess and your strengths and weaknesses. Space at the end of each intelligence allow you to write additional information not specifically referred to in the inventory.

Body/Kinesthetic Intelligence
__I engage in at least one sport or physical activity on a regular basis.
__I find it difficult to sit still for long periods of time.
__I like working with my hands at concrete activities such as sewing, weaving, carving, carpentry, or model building.
__My best ideas often come to me when I'm out for a long walk or a jog, or when I'm engaged in some other kind of physical activity.
__I often like to spend my free time outdoors.
__I frequently use hand gestures or other forms of body language when conversing with someone.
__I need to touch things in order to learn more about them.
__I enjoy daring amusement rides or similar thrilling physical experiences.
__I would describe myself as well coordinated.
__I need to practice a new skill rather than simply reading about it or seeing a video that describes it.

Other Body/Kinesthetic Strengths:

Interpersonal Intelligence
__I'm the sort of person that people come to for advice and counsel at work or in my neighborhood.
__I prefer group sports like badminton, volleyball, or softball to solo sports such as swimming and jogging.
__When I have a problem, I'm more likely to seek out another person for help than attempt to work it out on my own.
__I have at least three close friends.
__I favor social pastimes such as Monopoly or bridge over individual recreations such as video games and solitaire.
__I enjoy the challenge of teaching another person, or groups of people, what I know how to do.
__I consider myself a leader (or others have called me that).
__I feel comfortable in the midst of a crowd.
__I like to get involved in social activities connected with my work, church, or community.
__I would rather spend my evenings at a lively party than stay at home alone.

Other Interpersonal Strengths:

Intra-personal Intelligence
__I regularly spend time alone meditating, reflecting, or thinking about important life
I have attended counseling sessions or personal growth seminars to learn more about myself.

I am able to respond to setbacks with resilience.

I have a special hobby or interest that I keep pretty much to myself.

I have some important goals for my life that I think about on a regular basis.

I have a realistic view of my strengths and weaknesses (borne out by feedback from other sources).

I would prefer to spend a weekend alone in a cabin in the woods rather than at a fancy resort with lots of people around.

I consider myself to be strong willed or independent minded.

I keep a personal diary or journal to record the events of my inner life.

I am self-employed or have at least thought seriously about starting my own business.

Other Intra-personal Strengths:

Logical/Mathematical Intelligence

I can easily compute numbers in my head.

Math and/or science were among my favorite subjects in school.

I enjoy playing games or solving brainteasers that require logical thinking.

I like to set up little "what if" experiments (i.e. "What if I double the amount of water I give my rosebush each week?")

My mind searches for patterns, regularities, or logical sequences in things.

I'm interested in new developments in science.

I believe that almost everything has a rational explanation.

I sometimes think in clear abstract, wordless, imageless concepts.

I like finding logical flaws in thing that people say and do at home and work.

I feel more comfortable when something has been measured, categorized, analyzed, or quantified in some way.

Other Logical/Mathematical Strengths:

Musical/Rhythmic Intelligence

I have a pleasant singing voice.

I can tell when a musical note is off-key.

I frequently listen to music on the radio, cassette tapes or compact discs.

I play a musical instrument.

My life would be poorer if there were no music in it.

I sometimes catch myself walking around with a jingle or other tune running through my mind.

I can easily keep time to a piece of music with a simple percussion instrument.

I know the tunes to many different songs or music pieces.

If I hear a musical selection once or twice, I am usually able to sing it back fairly accurately.

I often make tapping sounds or sing little melodies while working, studying, or learning something new.

Other Musical/Rhythmic Strengths:

Verbal/Linguistic Intelligence

Books are very important to me.

I can hear words in my head before I read, speak, or write them down.

I get more out of listening to the radio or a spoken-word cassette than I do from television or
films.
__I enjoy word games like Scrabble, Boggle, Anagrams, or Password.
__I enjoy entertaining myself or others with tongue twisters, nonsense rhymes, or puns.
__Other people sometimes have to stop and ask me to explain the meaning of the words I use in my writing and speaking.
__English, social studies, and history were easier for me in school than math and science.
__When I drive down a freeway, I pay more attention to the words written on signs than to the scenery.
__My conversation includes frequent references to things that I've read or heard.
__I've written something recently that I was particularly proud of or that earned me recognition from others.

Other Verbal/Linguistic Strengths:

Visual/Spatial Intelligence
__I often see clear visual images when I close my eyes.
__I'm sensitive to color.
__I frequently use a camera or camcorder to record what I see around me.
__I enjoy doing jigsaw puzzles, mazes, and other visual puzzles.
__I have vivid dreams at night.
__I can generally find my way around unfamiliar territory.
__I like to draw or doodle.
__Geometry was easier for me than algebra in school.
__I can comfortably imagine how something might appear if it were looked down upon from directly above in a bird's-eye view.
__I prefer looking at reading material that is heavily illustrated.

Other Visual/Spatial Strengths: