Matters of Style

EFFECTIVE EDUCATION TEACHES TO STUDENTS’ LEARNING STYLE WEAKNESSES AS WELL AS THEIR STRENGTHS.

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.”

BY RICHARD FELDER
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 ESTP (extravert, sensor, thinker, perceiver), and another may be an INFP (introvert, intuiter, 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 (HBDO). This method classifies students in terms of their relative preferences for thinking in four different modes that are based on the task-specialized functioning of the physical brain. The four modes or quadrants 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, kinaesthetic, symbolic;


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 in a 1995 Journal of Engineering Education article. Most engineering instruction consequently focuses on left-brain Quadrant A analysis and Quadrant B methods and procedures associated with...
levels and attitudes to the course improved considerably be-
cause of these changes.

These results and the results of similar studies led Edward
and Monika Lumsdale to conclude in a 1995 Journal of Engi-
neering Education article that the HBDE can serve several im-
portant 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 prefer-
ences; helping instructors and students form whole-brain
teams for optimum problem solving; and assessing the influ-
ence of curriculum changes on individual and collective student
thinking skills. (For more information, contact Edward Lums-
daine, usfmdn@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. (The ILS
may be viewed and downloaded from http://www2.nccsu.edu/unity/lockers/users/felder/public/ILSPage.html.)

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 engineer-
ing instruction by increasing the use of methods oriented to-
ward 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 informa-
tion, contact Peter Rosati, prosati@charon.engg.uwo.ca.)

At the University of Michigan, Susan Montgomery, an assis-
tant professor of chemical engineering, is developing multi-
media instructional modules that address the spectrum of
Felder-Silverman preferences. To do this, she assessed her stu-
dents’ learning styles with the ILS and surveyed them to deter-
mine the attitudes of the different types toward different fea-
tures 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 instruc-
tor 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 informa-
tion, contact Susan Montgomery, smontgomery@engin.umich.edu.)

In another learning style-based approach to software in-
struction, Curtis Carver and Richard Howard, assistant pro-
fessors at the U.S. Military Academy, have developed a hyper-
media 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 differ-
ent 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 sequen-
tial learners. Or they can learn the same thing by viewing em-
bedded 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 in-
terface then provides them the option of having the material
presented in a manner compatible with their style prefer-
ences—structuring the lesson so that the preferred media ele-
ments come first. Students who prefer to organize the presenta-
tions themselves may do so also. (The hypermedia package can
be accessed at http://www.eecs.usma.edu/cca383/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 chemi-
cal engineering courses in a way that would appeal to a range
of learning styles. I presented course material inductively, mov-
ing from facts and familiar phenomena to theories and mathe-
matical models rather than always using the “fundamentals,
then applications” approach. I used realistic examples of engi-
neering 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 aug-
mented traditional formula substitution problems with open-
ended questions and problem formulation exercises. I used ex-
tensive 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, contact Richard Felder, felder@eos.ncsu.
edu.)

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; the instructional approaches that
reach around the cycle for each of the models are essentially
identical. Whether educators are designing a course or curricu-
lum; writing a textbook; developing instructional software;
forming cooperative learning teams; or helping students devel-
open interpersonal, leadership, and communication skills; they
will benefit from using any of these models.

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cal Engineering at North Carolina State University.
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, 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.

- In every course, 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 $y = x^2$ 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 as 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 Kirchhoff’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 plants, coal boats, 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.
with that analysis, neglecting important skills representative of 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 the 20 to 40 percent 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 “Teaching to All Types,” page 23, I suggest some instructional methods for addressing the learning needs of the full spectrum of styles.

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**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 labels; the student is the ultimate judge of his or her behavior patterns.

Working with an ISTJ (introvert, sensor, thinker, judge) 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 (extravert, intuit, thinker, judge) student jumped directly into mathematical derivation on every homework and test problem (behavior consistent with extraverted 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.iu.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 Kolb 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 important, she says, it helps them develop interpersonal skills that are critical to success in any professional career. (For more information, contact Julie Sharp, sharpje@nise.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 Voite, then of the University of Toledo’s engineering college, studied the HBDI types of the college’s students and faculty. 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 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 Voite 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

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**Additional Reading**

For more information on each of the learning style models discussed in this article, you may want to check out the following sources.

**HERRMANN BRAIN DOMINANCE MODEL**


**KOLB LEARNING STYLE MODEL**


**MYERS-BRIGGS TYPE INDICATOR**

Lawrence, G. *People Types and Tiger Stripes* (3rd ed.). Gainesville, FL: Center for Applications of Psychological Type, 1994.
