

PRESENTATION ON LEARNING STYLES/MULTIPLE INTELLIGENCES
to
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I first got interested in learning styles from a presentation at a NSTA conference I attended one year. About that same time, or shortly after, I saw an interview with Howard Gardner of Harvard University who was explaining his theory on multiple intelligences and I felt that this could be very applicable in chemistry education. The project I presented at Waterloo last year was done in the context of reaching various learning styles in chemistry education.

This past summer I did some reading to educate myself on the topic. I started with a book by Howard Gardner: "Frames of MInd: The Theory of Multiple Intelligences". Gardner is actually a researcher in neuropsychology who studies prodigies, idiots savants, brain-damaged persons, normal children, autistic children, children with learning disabilities, experts and people of diverse cultures. He combined his results with research findings in genetics, psychology, neurobiology, history and philosophy, international development and anthropology and in the early 1980's came up with his theory of multiple intelligences, that there are at least seven relatively autonomous human intelligences, or ways through which people learn. He rejects the traditionally-accepted criteria of intelligence and instead defines an intelligence as a set of skills that enables one to resolve genuine problems or difficulties or to create an effective product. The seven intelligences he has identified are linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, interpersonal and intrapersonal. He is critical of traditional testing which emphasize logical-mathematical intelligence above all others and describes as risky the assumption that the processes required for performance on these tests are those directly involved in learning. Tests, he says, are good predictors of school performance rather than of professional performance, since they tend to obscure the abilities of individuals who are weak in linguistic and logical-mathematical abilities, the traditional media of institutionalized education. Although he is critical of the use of "intelligence" tests, the correlation that he saw among different psychological tests and the results of skill training led him to conclude that, generally, individuals use different intelligences for different kinds of information and may make use of several intelligences to solve a particular problem. These information-processing approaches reflect intellectual strengths or natural competencies and are always an interaction between biological proclivities and the opportunities for learning that exist within a culture. According to Gardner, while all these cognitive capabilities are found in normal people, individuals develop natural proclivities to learn via particular "biopsychological potentials" as a result of heredity and early training. Both biological proclivity and cultural nurturing determine the distribution of intelligences in an individual. Although genetic factors might set an upper limit for a particular intellectual potential, which he says is, practically speaking, seldom approached, the needs of a person's culture is what determines the extent to which a given intelligence is realized. It should be possible, he maintains, to identify an

individual's natural proclivities and then by making the method of transmission of information coincide with the learner's natural competence, educational opportunities and options will be enhanced and each person will be enabled to achieve optimum learning. Gardner believes that persons with low proclivity in requisite directions can be initiated into the relevant knowledge through other intellectual competences in which they naturally have strengths. This way they are used as entry points for learning. These multiple intelligence entry points (e.g. narrational, logical-quantitative, foundational, esthetic, experimental) he likens to doors which permit students to enter the conceptual "room" via the most comfortable entrance, then once inside, they are able to explore the room and utilize other entry points. He says that any rich, nourishing topic, any topic worth teaching, can be approached in at least five different ways that map on to a variety of intelligences.

Gardner was completely taken by surprise that practising educators rather than psychologists were the ones who showed overwhelming interest in his work. It is out of this interest that he edited a reader, "Multiple Intelligences: The theory in Practice" which is a collection of papers which report the application of his theory in actual situations.

Learning style theory, on the other hand, comes out of research by cognitive psychologists and is defined as "characteristic cognitive, affective and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment". A book edited by Ronald and Serbrenia Sims, "The Importance of Learning Styles: Understanding the Implications for Learning, Course Design, and Education", is a collection of papers which discuss the implications of learning style theory to pedagogy. Since the 1960's, several studies on adult learning styles carried out in Australia, Europe and North America have appeared in various publications. The different theoretical approaches on which they were based led to different research approaches, with the result that resolving issues as fundamental as a universally acceptable definition of learning styles has proven difficult. Campbell (cited in Sims and Sims) observed a wide variation in terminology used in measuring learning styles, as well as how it is done, in spite of similarity among the instruments. An illustration of this is the work of a pair of researchers, Honey and Mumford, who studied managers and identified four learning styles: activist, reflector, theorist and pragmatist. A second illustration is the work of David Kolb, a leading proponent of learning style theory, who in the early 1980's conducted research which explored John Dewey's ideas about adult learners. He incorporated his findings into an Experiential Learning Theory (ELT) which identifies four learning modes: concrete experience, reflective observation, abstract conceptualization and active experimentation. Learning, he says, involves what the learner feels, perceives, thinks and does.

In reviewing the literature on learning styles, Geary and Sim found that in accounting education, diverse teaching approaches were needed since students have diverse learning styles. Sims and Sims concur that if one approach is used some students will not understand the material. Studies done by W. Purkiss for a doctoral dissertation at The

Claremont Graduate School showed that at the college level previously successful concrete learners are at a disadvantage when compared with previously less successful abstract learners. Other studies by McKenney, Guild and Fouts have found more learning style differences within a particular ethnic group than between ethnic groups in the United States and Fry and Kolb found that particular learning styles seem better suited for particular learning environments, and that students perform better in environments or approaches that complement their learning styles. The results of a learning style identification exercise administered by Reinert led him to recommend that students' initial contact with information to be learnt be via their most efficient learning style.

As we have seen, the evidence from learning style research is compatible with Gardner's theory and it is generally recognized that attention to more than content is required for effective teaching of the diverse student body represented in colleges today, yet many higher education instructors do not realize that students vary in the way they process and understand information. In chemistry, formal education in is conducted almost exclusively through linguistic and mathematical media. This is not surprising, given the finding that high mathematics scores and success in chemistry tend to go together, and the yet-pervasive assumption by education brokers that there is one way of teaching, one way of learning and that one's skill at achieving in this milieu indicates intelligence. Unfortunately, the majority of the general population is linguistically and mathematically challenged, and increasingly such persons are appearing in college chemistry classes. Although no one really knows how people learn, studies show that identifying one's learning style and providing appropriate instruction can contribute to effective learning. For example, Gardner identifies, as central to learning in the physical sciences, three intelligences: (1) logical-mathematical which is the ability to recognize ordered arrays and relate to abstract concerns that are linked to reality only by "a lengthy chain of inference, objective writing, reading and testing"; (2) spatial intelligence which is the capacity to perceive the visual world accurately, perform transformations and modifications on one's perceptions and recreate aspects even without relevant physical stimuli and (3), a minimum level of linguistic competence. Citing Piaget's findings that the basis for all logical-mathematical forms of intelligence is the handling of objects, first physically, later mentally, Gardner recommends translating a mathematical concept into spatial, linguistic or bodily-kinesthetic medium wherever this is possible in order to assist the learner in conceptualization. He warns, however, that the desired learning may not occur if the concept is not finally translated into the student's logical-mathematical intelligence.

Relevant to this is a study done, over a 12-year period, of the spatial perceptual skills of general chemistry students at Missouri State University and which showed statistically higher spatial perceptual skills among males. Interestingly, toward the end of the study the gender gap decreased due to a lowering of the males' scores. A question of interest is: Could this gap have been eliminated by increasing the female students' spatial perceptual skills by using alternative approaches? Francisco, Nicoll and Trautmann as well as Brown Wright found that multiple teaching strategies were well received by general chemistry students, and not only aided students with unusual learning patterns but were

useful for broadening the understanding of those who do well in the traditional classroom setting, since often they excel at "rote, repeat and give-back" rather than true understanding. Another study by Hunter and McCants in 1977 showed that younger college students preferred a more concrete experiential mode of learning. In 1995 Jones and Berger found that undergraduate students have different usage patterns for completing the same chemistry assignment, indicating that students are able to use individual learning styles in a well-designed multimedia chemistry instructional program. (J Educational Multimedia and Hyypermedia) and in the September, 1996 JChemEd Richard Felder describes a sequence of five experimental courses in chemical engineering that are designed to meet the needs of students with various learning styles. Niaz and Robinson found that students' ability to solve gas-law problems varied greatly, depending on the approach utilized, even with receiving training or experience (Research in Science and Technological Education, 1992). In 1973 Sam Castleberry et al of the University of Texas published a report of their successfully-designed chemistry multimedia course which incorporated information on student learning styles and generated individually-tailored remedial modules and at the 1991 NARST conference Nakhleh and Krajcik presented a paper reporting that with the aid of technology students' understanding of several chemical concepts improved. Software has been developed by the Chemical Engineering Department at the University of Michigan with the objective of accomodating learning style preferences.

Spencer (Sims and Sims) credits cognitive and classroom research with providing a paradigm shift toward greater sensitivity to the presence in today's chemistry classroom of different learning style and encourages instructors to organize learning environments and activities in a manner that involves telling, showing and doing. Still, in the April, 1999 issue of JChemEd, Dorothy Gabel bemoans the fact that chemistry education research has had little impact on the way chemistry is taught. Sims and Sims appeal to tertiary-education instructors to adjust their methods so as to accomodate the learning styles of their students. Wooldridge, citing studies which indicate that a high percentage of university and college students are field dependent, that is, very dependent on external stimuli such as interpersonal interaction and social atmosphere, recommends that research be pursued to determine the effectiveness of using technology. He makes reference to previous studies by McCleary and McIntyre, by Newstrom, by Olivas and Newstrom and by Carroll, Payne and Ivancevich which relate the effectiveness of a variety of instructional methods to specific learning objectives.

[From the above discussion it is clear that the concept of multiple intelligences naturally leads to a concern for "individual-centered" education, where the emphasis is on developing skills for solving problems that are important to the learner's way of life. An important aim of education should be to help people fully use their spectrum of intelligences, and it should be done in a manner that aids each person in maximizing his/her potential. People usually use one side of their brain more, but the other side can be stimulated, resulting in greater ability and effectiveness. By paying attention to models of how individuals learn, teaching that enhances learning can be implemented; neglect results in educational endeavors that fail to achieve results. Thus, the curriculum, the way

of teaching and the kind of life and work options available in the culture should all compliment each other. Technology that is currently available can facilitate this objective. Sims and Sims emphasize that unless learning is active and the learner directly involved in the process it is sterile, whether it involves problem solving or analyzing an issue relevant to information given. Effective learning results in permanent changes in behavior, capability and/or attitude and occurs when instructors affirm the presence and validity of diverse learning styles and maximize the climate and conditions for learning, taking account of learning differences and thus increasing the possibility of success for all learners.]

[It is imperative that appropriate methods of assessment be used. Since no instrument has 100% validity for everyone, more than one should be used in determining a person's learning style, preferably at least one from each of the three layers: instructional and environmental, informational processing, and personality-related. It is also important to study the validity and reliability test samples upon which the inventory is based and to bear in mind that they are for testing learning styles, not learning disabilities. Via interactive technology, instruments can be administered to test learning and to predict difficulties. An individual's preferred intelligence can be determined by noting the choice made (and how deeply it is explored) when the person is exposed to a multiple intelligence situation, such as the opportunity to perform a task via different intelligence routes, or simply to describe a scene. It has been observed that some learners' working styles are independent of content area whereas others' are a function of the subject matter. The results of such testing serve as guides in making appropriate adaptations of the curriculum and in choosing alternative routes to educational goals. This, of course, subsumes trained and motivated teachers supported by an aware and participating community. Gardner sees the development of curricular approaches tailored for individuals with different intellectual profiles as an area that is posed for progress.]

In her paper cited above, Gabel projects that in the next century classrooms will be a more diversified, international and heterogenous in terms of students' backgrounds. She sees research into how students' of diverse backgrounds, learning styles and abilities leading to a restructuring of the way chemistry content is presented, and that computers will play a facilitating role in achieving this goal.

I am proposing a research project for measuring the effectiveness of teaching a predetermined chemistry topic to accommodate learning styles. Three learning styles will be examined: linguistic, logical-mathematical and spatial. Students will be given a short diagnostic test which is relevant to learning chemistry. (An example may be 10 multiple choice questions, each presenting a problem and providing the answer plus items which give the "reason" the student feels most confident/comfortable with the answer to the question. Each item will represent one of the three learning styles under investigation. The predominant category of items chosen by a student will be taken as that student's preferred learning style. If an appropriate test is not already available, this test will need to be validated against already validated learning style tests.) Once the students are grouped by learning styles (I, II and III), each group will be divided into three groups, A,

B and C. The three A groups will be taught via learning style I, the three B groups via learning style II and the three C groups via learning style III. Each of the nine groups will be post tested and the correlation between learning style and teaching approach will be determined.