Chapter 1, The Geometry Of Education: Patterns For Growth

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The Congress of Neurological Surgeons (CNS) was founded more than 50 years ago by a group of young neurosurgeons seeking to fulfill their need for professional fellowship and education (8). Their primary focus was on education, and that sentiment continues to be reflected in the first sentence of our mission statement (Fig. 1.1). Although the CNS represents many things to many people, all recognize its commitment to excellence in education.

Professional education is a career-long endeavor; likewise, our personal education is never-ending. Educational needs are highly individualized because no two people have the exact same strengths or weaknesses. The purpose of this communication is to discuss education not only as it relates to neurosurgery, but as fundamental to our personal growth throughout our entire life.

The objectives and dimensions of education have been extensively studied. Three-quarters of a century of research suggests that educational objectives fall into three domains: the psychomotor or locomotor area, the cognitive area, and the affective area (1, 5, 7) (Fig. 1.2). The psychomotor area includes the development of a person's muscular or mechanical skills. In our specialty, these skills are primarily those physical activities we use in the operating room. Cognitive education aims at increasing a person's knowledge and intellectual aptitude. A great portion of formal neurosurgical education falls into this area, and it includes all of the factual information we must master and be able to access. The affective domain deals with feelings, values, and appreciations; and it includes both individual and collective social needs. Affective education is central in the development of moral and spiritual values, healthy attitudes and emotions, and satisfying relationships with others. Affective learning is not only key to being able to successfully interact with our patients and co-workers but it is also central to developing and nurturing self-respect and positive personal interactions and relationships.

It is relatively easy to understand how education is critical for the safe and effective practice of neurological surgery. There is the large volume of essential information concerning the circuitry of the basal ganglia, the biology of neurodegenerative disorders, spinal biomechanics, and numerous other facts that must be learned to provide the cognitive foundation of our specialty. The psychomotor skills necessary to safely and efficiently secure an aneurysm or correct a spinal deformity must be mastered. Structuring a residency program to fulfill these two objectives is relatively straightforward. Addressing the affective area of neurosurgical education, however, is more difficult. This is because of the subjectivity of the affective component and the tremendous influence exerted by each individual's personality and perspective. Collectively, neurosurgeons may be especially challenged in the affective area because of a selection bias. Ours is a technically oriented specialty that places great emphasis on cognitive and psychomotor functions. People generally choose careers that match their personal talents and, thus, as a group, our affective

learning skills are probably our weakest.

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The neurosurgical educational experience is intense, and the final product results from the efforts of both the individuals and the people surrounding them. Neurosurgeons view the educational model classically, as being comprised of a teacher and student who share a unique relationship. The flow of critical information is two-way, and the educational process is experienced jointly. The connection is complex, because in any interaction, each participant at any time may be the teacher, the student, or even both. It should always be remembered that the student is always the most important person in the educational process. Mastering the large bodies of factual information necessary to practice neurosurgery is arduous. Much of this work must be accomplished alone, during long disciplined hours with books, anatomical atlases, and journal articles. This process must be self-motivated, because all of the written materials, courses, and conferences will not educate the disinterested. During this phase of learning, students serve to a large degree as their own teachers. Although critical to achieving a positive end result, independent and isolated self-study alone is inadequate. Neurosurgical students must also be open to the influence and advice of all of the people engaged in the process: faculty, peers, hospital staff, patients, family, and friends. It is from these people that we learn the art of medicine and surgery, how to work as members of the health care team, to relate and interact with patients on a personal level, and to understand our professional roles in society. As with all endeavors, there are leaders. Good leaders do not dictate, order, intimidate, or cajole, but, rather, influence and motivate others by the examples they set. Their qualities inspire us to follow them. Robert Nugent is an example of an educational leader (Fig. 1.3). Over the course of his career, he has been the consummate clinician and surgeon. He has worked to keep his fund of knowledge current and he continues to graciously accept requests to serve on the faculty in courses such as those held at this meeting. As a residency director, he almost never praised good performance and rarely uttered a criticism, yet his educational leadership skills were so accomplished that he garnered his students' greatest respect. This was particularly evident during conferences. Each resident desperately wanted to be able to answer his questions correctly. Hearing a wrong answer, Dr. Nugent's face would subtly convey disappointment, but just for a moment. That was enough to make us feel as if we had let him down, failed him in some way. That feeling would strengthen our resolve to work and study harder. He had empathy for his patients and was able communicate well with them. This man of great humility was the complete teacher—sharing and demonstrating his cognitive, psychomotor, and affective knowledge. Individuals such as Dr. Nugent are the educational leaders within our specialty.

Many other important healthcare professionals provide critical daily care for our patients. Neurosurgeons may possess great cognitive and psychomotor skills referable to neurosurgery, but our allied health care partners can share key portions of their different, but complementary, knowledge bases with us. I am certain that every neurosurgeon in this room

can relate a number of useful and valuable things that were learned from nurses, x-ray technicians, physical therapists, or other members of the health care team. These individuals often provide particularly vital instruction in the affective arena.

For example, I treated a 22-year-old man with a radical cranial base resection for sinonasal undifferentiated carcinoma. For 3 days after surgery he appeared to be unresponsive. The cause for his condition could not be determined despite multiple imaging studies, blood tests, and electroencephalograms. I was extremely concerned; however, a nurse caring for him during those days told me she was certain that he was responding to her. How many times do we dismiss a neurological examination incongruent with our own? This patient did recover and, amazingly, could describe almost everything that took place during those days immediately after surgery. He must have been in a locked-in state, perhaps caused by frontal lobe retraction. The nurse was the teacher, and her intuition and perception were correct. We need to listen to others.

We must always be open to the possibility that we are wrong or not fully informed. This does not have to do specifically with the medical sciences. How many times have others, such as your spouse or children, related a feeling based on intuition or with some other "nonscientific" rationale? Do not discount the prospect that they are correct.

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Consider that, at this very moment, hundreds, perhaps thousands, of cell phone calls are passing through you. Think about it—the radio waves are real although we cannot perceive them. Intuitive and creative people reach out, engage, and tap into sources that seem to be as nonexistent as radio waves. Listen to those individuals and let them teach you.

Neurosurgery is a clinical subspecialty, and the patient should always be our primary focus. Every day we teach patients about their condition and they look to us for advice. But, we also learn from them. We learn factual information, particularly concerning our own management outcomes, yet we must also be aware of the other lessons they can teach, which are primarily affective—a weak knowledge area for many of us.

I remember a young lady who had just graduated from college when she developed a dominant temporal lobe glioblastoma. After resection, she was treated with radiation therapy and chemotherapy, yet, with time, and as expected, the tumor recurred. She ultimately underwent several more operations for local recurrence. Each surgery was followed with a different chemotherapy regimen. She remained in good condition and was very functional despite a minor seizure disorder. Properly, she was educated on epilepsy and the clinical treatment and course of glioblastomas. She was an intelligent person and she understood her situation. Approximately 2 years after her first operation, she stopped her anticonvulsant medications against medical advice, conceived, and gave birth to a healthy baby girl. She was ecstatic. When she was 28, the tumor took her life. Although many years have passed, I

have never forgotten her. She was an unfortunate and difficult patient who taught me many things. Perhaps the most important one was that just because her decisions were not concordant with an analytical medical thought process, they were not wrong. She was in control of her life, knew what she wanted, and made choices on lifestyle issues that went beyond the cold reality of her disease process. Once educated, all persons, including our patients, have the right to make their own decisions, and these decisions must be respected.

While in school, we purchase education with tuition and fees. Education is a means to an end; it provides the tickets to allow us to enter our chosen profession. Once we finish formal training, we must become even more complete, autonomous, and self-driven students. There are obvious reasons why it is important to continue learning. Learning prepares you to deal positively and productively with change. Many business professionals change jobs frequently in today's society. Although we may not change our job, our job changes. Almost 50% of the neurosurgical procedures differ from those of 15 years ago, and many did not even exist then.

Expanding our knowledge through continued learning allows us to keep up-to-date on the cognitive and psychomotor advances referable specifically to neurosurgery. We are also able to learn and incorporate nonspecialized information into our practices, such as strategies to assess contracts, avoid litigation, lobby for political change, and so forth.

Furthermore, there is overwhelming evidence that using our minds will help keep us mentally sharp and socially engaged. Learning and then using that new knowledge is the best way to use our minds. It may sound simple and trite, but education does lead to success. How can we use education to pursue a successful and satisfying life?

Charles Handy, in his book, The Age of Paradox, wrote, "It is one of the paradoxes of success that the things and ways that got you there are seldom those things that will keep you there" (2). Handy offers a solution to this dilemma. The normal pattern of growth can be considered as a curve. Initially, the curve has an upward slope which is analogous to our acquiring knowledge and experience. It then reaches its peak and begins to decline. The secret to constant growth is to start a new curve before the first one declines (Fig. 1.4). The new curve must be started and soundly rising before the first curve begins to dip downward. It is education that defines the all-important positive slope of the curve in this analogy.

Now life is exceedingly complex and there often seems to be no pattern that will link events, endeavors, experience, and success; therefore, it may seem elementary to think that it could all be described with a single linear model, such as Handy's curve. The curve, however, is only a part of this model.

Benoit Mandelbrot, in the seminal publication, The Fractal Geometry of Nature, defined what has become the science of chaos (6). This new science offers a way of seeing order and pattern where formerly only the unpredictable, the erratic, the chaotic had been observed. The word fractal relates to a way of describing, calculating, and thinking about shapes that are infinitely irregular and fragmented.

Imagine a triangle, each of its sides equal in length. Now imagine a transformation using a particular, well-designed set of rules. Take the middle third of each side and attach a new triangle, identical in shape, but one-third the size. If the process is repeated infinitely, the outline becomes more and more detailed. This particular model is known as the Koch snowflake (4) (Fig. 1.5). The Koch snowflake is a continuous loop, never intersecting itself, because the new triangles on each side are always small enough to avoid bumping into each other. Each transformation adds a little area to the inside of the curve, but the total possible area remains finite, not much bigger than the original triangle. In fact, if you drew a circle around the original triangle, the Koch snowflake would never extend beyond it (Fig. 1.6), yet the loop is infinitely long. A paradoxical result: infinite length enclosing finite space. Such paradoxical processes are not limited to two dimensions. A three-dimensional analog is the Menger sponge, a solid-looking lattice that has an infinite surface area but zero volume (3). The Koch snowflake can be described in terms of fractals, which implies an organizing structure that lies hidden among its intricate complication.

The journey of our life can be viewed as a solitary curve, as described by Handy, but only from the perspective of distance. Examination of any portion under high magnification will reveal a convoluted and chaotic-appearing series of countless curves. These curves represent every undertaking we attempt. They are multidimensional, and although they define our journey, they do not totally control it. In every tiny curve we need to strive for success. Continued success in that area requires the constant creation of more curves. Education allows us to identify new curves and build them with a positive slope.

Consider the curves and your life in terms of fractals. There are an infinite number of possibilities to succeed compressed into a finite number of years. Visualize the positive slope of each curve as a small portion of Koch's snowflake with countless tiny triangles (Fig. 1.7). These triangles may represent the cognitive, psychomotor, and affective educational objectives. The length of each side will vary relative to the primary domain of the particular endeavor represented by that curve.

How can we build positive, balanced slopes? CNS educational offerings provided by our journal, NEUROSURGERY, our annual meeting, and Sans Wired, to name a few, can help us gain specific knowledge within our specialty. We need to seek and emulate the positive examples of leaders such as Bob Nugent. We need to grasp the educational opportunities presented by our professional colleagues, our allied health partners, and our patients. Outside of neurosurgery, we can accumulate knowledge from countless sources—print and broadcast media, community courses, and, most importantly, people. Spouses, children, and friends can provide not only knowledge, but also lead and educate us through example. Finally, do not neglect to learn from your successes and, more importantly, your own mistakes. We cannot undo our errors, but we can take steps to prevent such things from occurring in the future.

Create a plan to achieve success in every undertaking. Visualize each curve of the plan from both distant and close perspectives. Balance your educational triangles in such a manner that you can construct new positive curves regularly. Take care not to neglect affective knowledge. Imagine yourself surfing not from wave to wave but continuously riding each wave directly to a larger one without ever stopping. Keep your mind open to every educational opportunity, and the potential for professional and personal

growth will truly be infinite.

References

1. Bloom BS, Englehardt D, Furst EJ, Hill WH, Krathwohl DR: Taxonomy of Educational Objectives. The Classification of Educational Goals. Handbook I: Cognitive Domain. New York, David McKay, 1956.

2. Handy C: The Age of Paradox. Boston, Harvard Business School Press, 1994.

3. http://www.fatdays.com/fractals/MmaNotebooks/fractals/fractals_5_1_0.html. Accessed 1/5/05.

4. http://www.math.sunysb.edu/~scott/Book331/Recursion_making_Koch.html. Accessed 1/5/05.

5. Krathwohl DR, Bloom BS, Masia BB: Taxonomy of Educational Objectives. The Classification of Educational Goals. Handbook II: Affective Domain. New York, David McKay, 1964.

6. Mandelbrot B: The Fractal Geometry of Nature. New York, Freeman, 1977.

7. Moore KD: Classroom Teaching Skills. New York, McGraw-Hill, 1992, ed 2, pp 64–65.

8. Thompson JM: History of the Congress of Neurological Surgeons 1951–1991. Baltimore, Williams & Wilkins, 1992.

FIG. 1.1. Mission statement of CNS.
FIG. 1.2. Educational domains.
FIG. 1.3. Robert Nugent.
FIG. 1.4. A, Handy's curve. B, continued success requires multiple curves.
FIG. 1.5. Construction of Koch's snowflake.
FIG. 1.6. The total area within Koch's snowflake is finite.
FIG. 1.7. A portion of Koch's snowflake superimposed on Handy's curve.