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Some Reasons for the Effectiveness of Fractals in Mathematics Education

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Short is the distance between the elementary and the most sophisticated results, which brings rank beginners close to certain current concerns of the specialists. There is a host of simple observations that everyone can appreciate and believe to be true, but not even the greatest experts can prove or disprove. There is a supply of unsolved, elementary problems that give students the opportunity to learn how mathematics can be done by enabling them to do new (if not necessarily earth-shaking) mathematics; there is a continuing flow of new results in unexpected directions.

1. Introduction

In the immediate wake of Mandelbrot (1982), fractals began appearing in mathematics and science courses, mostly at the college level, and usually in courses on topics in geometry, physics, or computer science. Student reaction often was extremely positive,

1.1 The early days

A few years ago, the popularity of elementary courses using fractals was largely credited to the surprising beauty of fractal pictures and the centrality of the computer to instruction in what lies behind those pictures. A math or science course filled with striking, unfamiliar visual images, where the computer was used almost every day, sometimes by students? The early general education fractals courses did not fit into the standard science or mathematics format, a novel feature that contributed to their popularity.

1.2 What beyond novelty?

We shall argue that novelty was neither the only, nor the most significant factor. But even if it had been, and if the popularity of these courses had declined as the novelty wore off, so what? For a few years we would have had effective vehicles for showing a wide audience that science is an ongoing process, and exciting activity pursued by living people. While introductory courses for major are appropriate for some nonscience students, and qualitative survey courses are appropriate for some others, fractal geometry provided a middle ground between quantitative work aiming toward some later reward (only briefly glimpsed by students not going beyond the introductory course), and qualitative, sometimes journalistic, sketches. In general education fractal geometry courses, students with only moderate skills in high school algebra could learn to do certain things themselves rather than read forever about what others had done. They could grow fractal trees, understand the construction of the Mandelbrot and Julia sets, and synthesize their own fractal mountains and clouds. Much of this mathematics spoke directly to their visible world. Many came away from these courses feeling they had understood some little bit of how the world works. And the very face that some of the basic definitions were unsettled, and that there are differences of opinion among leading players, underscored the human aspect of science. No longer a crystalline image of pure deductive perfection, mathematics is revealed to be an enterprise as full of guesses, mistakes years of humanities and social science students a friendlier view of science and mathematics.

Fortunately, anecdotal evidence suggests that, while much of the standard material and computerized instruction techniques are no longer novel, the audience for fractal geometry courses is not disappearing, thus disproving those fears.

1.3 What aspects of novelty have vanished?

Success destroyed part of the novelty of these courses. Now images of the Mandelbrot set appear on screen savers, T-shirts, notebooks, refrigerator magnets, the covers of books (including novels), MTV, basketball cards, and at least one crop circle in the fields near Cambridge, UK. Fractals have appeared in novels by John Updike, Kate Wilhelm, Richard Powers, Arthur C. Clarke, Michael Crichton, and others. Fractals and chaos were central to Tom Stoppard's play Arcadia, which includes near quotes from Mandelbrot. Commercial television ("Murphy Brown," "The Simpsons," "The X-Files"), movies ("Jurassic Park"), and even public radio ("A Prairie Home Companion") have incorporated fractals and chaos. In the middle 1980s, fractal pictures produced "oohhs," "aahhs," and even stunned silence; now they are an ingrained part of both popular and highbrow culture (the music of Wuorinen and Ligeti, for example). While still beautiful, they are no longer novel.

A similar statement can be made about methodology. In the middle 1980s, the use of computers in the classroom was uncommon, and added to the appeal of fractal geometry courses. Students often lead faculty in recognizing and embracing important new technologies. The presence of computers was a definite draw for fractal geometry courses. Today, a randomly selected calculus class is reasonably likely to include some aspect of symbolic or graphical computation, and many introductory science classes use computers, at least in the lab sections. The use of computers in many other science and mathematics courses no longer distinguishes fractal geometry from many other subjects.

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