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UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

REVEALING THE POTENTIALITY FOR CHAOS IN A PUBLIC HIGH SCHOOL

A Dissertation

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

Doctor of Philosophy

By

SUSAN L. ERWIN
Norman, Oklahoma
2002

UMI Number: 3042511

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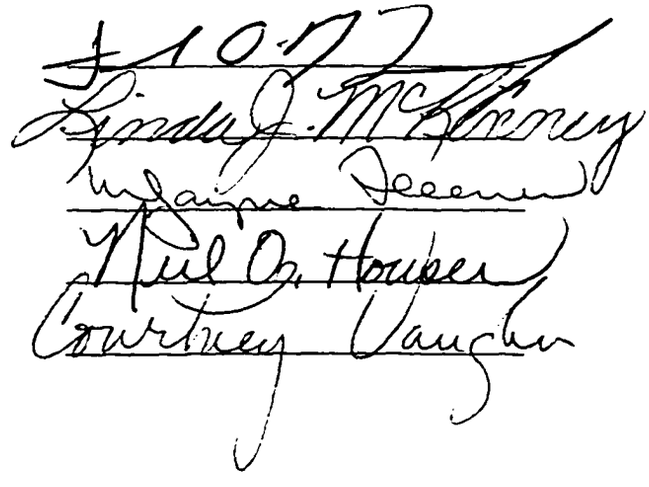
A dissertation APPROVED FOR THE
DEPARTMENT OF INSTRUCTIONAL LEADERSHIP
AND ACADEMIC CURRICULUM

BY



ACKNOWLEDGEMENTS

In many ways this dissertation serves as a culmination of my experiences in a public high school, as a student, a teacher, and a researcher. The number of people who have contributed to this experience is infinite. I cannot separate my own experiences from the context of relationships I developed with administrators, teachers, and student during the process. Indirectly, I have also been affected by the families of these individuals as well as by the wider community. These relationships have altered my perspective and changed me in ways I am only beginning to understand. To all of these people, I am sincerely grateful. Throughout my teaching career, these relationships have enabled me to grow and become.

In particular, I am grateful to all the men and women who helped me envision a public high school through the metaphors of the new sciences. I was impressed with their willingness to take time out of their busy lives to voluntarily learn something new, for the sake of helping me see the school in a new way. Their collective experiences and insights provided invaluable information, allowing me to view the school from multiple perspectives. Because of their help, I was able to approach a more holistic vision of the public high school.

I could not have embarked on this journey without the support and encouragement of an outstanding committee of professors at the University of Oklahoma. It has been a sincere honor and privilege to work with each of them. Their commitment and support during my quest gave me the confidence and freedom to develop a dissertation that would be personally meaningful to me. I am thankful to Dr. M. Jayne Fleener for introducing me to the wonders of the new sciences and a

spiritual meaning that has been brought back into my life. I never ceased to be impressed by the depth of her knowledge, or amazed by her ability to *teach* complex ideas to students with limited math or science backgrounds. Her intellectual curiosity and her willingness to explore new concepts inspired me. She taught me to value the journey in learning far more than the destination. I also thank Dr. Neil Houser for reawakening my social consciousness and helping me understand issues of power and powerlessness. He helped me realize that we all understand things from unique perspectives, and those perspectives are influenced by culture, class, race, gender, and more. This insight helped me tremendously in understanding the complexities of learning relationships in schools. Dr. Courtney Vaughn's help was essential to this study. She helped focus my study and search for answers to questions that were important to me. She encouraged me to seek a methodology that suited the question I hoped to answer, rather than try to fit my study into a particular methodology to meet other's expectations. This study could not have been completed without the use of the heuristic methodology that she introduced me to or the enthusiastic support she gave this study. Finally, my thanks to Dr. Linda McKinney and Dr. Frank McQuarrie for giving me the freedom to direct the course of my program and embark on a somewhat non-traditional research project. Your suggestions and recommendations improved both the quality of my performance and depth of my understanding. A special thanks to Dr. McQuarrie, a master teacher, who spent hours advising, meeting, discussing, encouraging, and editing, reading and re-reading drafts. He nurtured and facilitated my efforts from the very beginning, helping me set realistic and attainable goals. A

finer committee could not have been assembled. My expressions of gratitude are inadequate to communicate my appreciation.

Finally, I would like to thank my family for both inspiring my decision to return to school and supporting me in my effort. I would especially like to thank my husband, John, who chose to take this journey with me. His humor, encouragement, wisdom and love made the process both enjoyable and memorable.

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ABSTRACT

This study is a qualitative investigation of the experience of seeing a high school through the metaphors of the new sciences of chaos and complexity. The heuristic research methodology was employed in an attempt to find postmodern meaning not previously considered in the research surrounding education. Data were collected through observations and field notes of the researcher as well as through interviews with other school personnel. Relying on the faculties of tacit knowledge, the researcher became immersed in the study, allowing the data to indwell, to incubate and, finally, to illuminate the hidden dynamics of the public high school as seen through the metaphors of the new sciences of chaos and complexity.

Viewing the school as an organic, self-organized system, this study specifically explicates the new science tenets of: systems thinking, interconnection, relationship, open and closed systems, limit cycles, non-linearity, sensitive dependence on initial conditions, bifurcation points, irreversibility, self-organization, strange attractors, fractals and holograms, and learning.

Additionally, several emergent themes from the study are explicated. (1) In a high school everything is related and interconnected. (2) Everything that occurs in the school has consequence. (3) The patterns of the school change frequently while the structures of the school change less frequently, making it appear at times that everything changes and while nothing changes. (4) Linear reforms can not adequately address the needs of nonlinear schools. (5) Power, predictability, and control issues are frequently misunderstood by the community and reformers.

The heuristic methodology utilized in this study is critiqued and study findings are related to the current literature. Implications and recommendations are made to educators and education reformers. Finally, suggestions are offered for further research.

Chapter 1

In this chapter, I will present an account of the events leading ultimately to my decision to embark on this particular study. After explaining the need for research in this field, I will delineate the steps used in heuristic research to formulate my research question: What is the experience of *seeing* a public high school through the metaphors of the new science of complexity? By describing both the limitations and delimitations of this study, I will set the boundaries for the scope of this study. Finally, relevant terms will be defined in an effort to clarify as closely as possible both the intent and the findings of this study.

Background of the Study

Imagine a cramped, seemingly airless, high school biology classroom on a balmy September afternoon in 1966. Thirty-eight drowsy, slightly sweaty, and hormonally driven sophomores have settled into their assigned seats, occupying themselves with their own personal social or emotional concerns while the teacher finishes calling roll. The instructor, an elfin, five feet tall in heels, presents the day's lesson using her customary thick and syrupy Georgia drawl. On most days, the students decipher her accented delivery well enough to decode the gist of what she means. But today she will explain the difference between *micro*-organisms and m*acro*-organisms. Though discernibly different in print, these words have no perceptible contrast when pronounced in *southernese*. Like any self-respecting sophomore enrolled in that class, I would never think to actually read the chapter. Instead, I spent that week in total confusion, unable to distinguish the difference. I felt like an idiot and decided science was not going to be *my thing*. Though I don't

remember any particular assignment, test, or activity for that chapter, I do remember a feeling of utter, complete frustration. Perhaps unfairly, I still consider the perplexity of this single, ancient experience as a turning point in my academic career and, consequently, in my life. Earlier memories do not evoke any disinclination toward science, but subsequent recollections expose a reluctance to enroll, let alone excel in any *required* science class I was forced to take during the remaining years of high school and college. After my tenth grade ordeal, not only did I avoid additional course work in that field, but I developed a non-scientific (sometimes anti-scientific) viewpoint. Innocently, I was pulled by the currents of the *soft* social sciences while the *hard* sciences revolved outside my universe - a foreign space. I now see that a small, seemingly insignificant, unplanned event occurring at the age of 16 altered my intellectual mien for the next 32 years.

I cannot envision a scenario that might have compelled me to read a physics book three years ago. Traditional science (and its presentation and arrogance) robbed my world of any mystery. I was indoctrinated in the belief that Newton's clockwork universe accurately predicted everything; every question was solvable. Adhering to scientific procedure, the answer would always follow. If a query could not be quantified, it was not worth knowing. That was traditional science from my point of view. It was intimidating, but at the same time, I innately distrusted this notion. I sensed inconsistency in science that worked so methodically and mechanistically yet allowed for some data to be ignored, or thrown out altogether. Within such an exacting world-view, it seemed contradictory to me that data could be disregarded and small fluctuations in the data were acceptable. Scientific method answered many

questions, but it failed to answer many questions I asked. Traditional science marginalized me, making my questions unworthy of serious consideration.

Part of the problem was that I had always been more intrigued with exceptions than with generalities. My decision to work in the field of special education forced me to focus on exceptions to the norm on a daily basis. I discovered in my work that exceptional behaviors were often complex versions of normal behaviors, but they were not aberrations. In the 1970s and 1980s, society viewed the children I taught as *broken*. The school system had culled them. As statistical outliers they were segregated in special classes and labeled *other* than the norm. As I saw more children fall into expanded special programs, I wondered if perhaps the system was broken, rather than the children. When I left special education to teach regular high school history classes, I realized that *special* children were not much different than the *normal* ones. Returning to the special education field 12 years later, I began to speculate what set of events brought about the testing and placement of some children and not others. By the 1990s, educators began to realize that many of these learning difficulties were the result of more complex issues, not simply *broken* children. Apparently, a plethora of factors influenced a child's learning including: teaching methods, poverty, abuse, and others. Abnormalities were becoming the norm.

During the three decades following my sophomore biology class, none of my teachers could have predicted that I would develop this study, which bridges the principles of a *hard* science, physics, with the practice of a *soft* science, education. I did not expect it myself. Certainly, this incipient interest was unsought and unplanned on my part, germinating from a chance encounter with an unfamiliar body of

knowledge. I was first introduced to the concepts of chaos theory while reading Margaret Wheatley's (1992), Leadership and the New Science during the spring of 1999, shortly after beginning my doctoral work. I was intrigued by these new ideas and I was impressed with Wheatley's ability to describe complex, *hard* scientific principles, while giving concrete applications of these principles in the *soft* science of business leadership. Instruction in another required class I took that semester, rotated among the professors within the department each semester. By fortunate coincidence, the instructor assigned during my enrollment happened to be an ardent proponent of chaos theory. It was during this class that my interest was piqued enough to enroll in a course centering on chaos theory and the science of complexity the following summer. As a result of that class, my own reality metamorphosed. *Hard* science became a central part of my life. But it was a different science - a new science.

It was from this background and bias that I enrolled in my first statistics class. I fretted endlessly when data cleaning. I could not reconcile myself to the arbitrariness of designating data outliers, nor could I accept the use of mathematical contrivances developed to normalize curves for data that naturally fell askew. I had trouble letting go of data. If data *existed*, I felt it must mean *something*. To me, when data said something that didn't *fit* within normal bounds - the bounds were wrong, not the data. By midterm the reality of what *hard* science was, crashed in on me. The universe didn't operate the way I had been programmed to believe. To some extent, it seemed that reality existed only in the *cooked* numbers of statisticians. I suspected some scientific facts were based on statistical fancy. The feigned objectivity of the mechanistic, Newtonian model was in truth reliant upon the subjectivity of the

researcher when selecting which data to ignore and which data to transform, not to mention the nature of the study, and the way research questions were posed. I was astounded to see how much the outcome of a study depended on a researcher's preferences. The *Truth* found through the *hard* sciences was no more objective than the *Truth* found through the social sciences.

Earning a bachelors degree in history in the early 1970s, I witnessed the department struggle for legitimacy, attempting to classify itself a social *science* rather than social *study*. Failing to concern myself with the politics of the issue, I accepted, (without complaint), a degree entitled bachelors of *arts* rather than *science*. When I entered the employ of the public school system, I found history teachers derided by the *real* scientists as too subjective to be scientists. As education reformers called for greater emphasis on the sciences and math, I began to resent the implication that what I taught was less important. It was not until my statistics class that I finally realized that the *real* scientists simply hid their subjectivity behind numbers rather than disclosing it up front. The emperor had no clothes! More and more I felt the need to question everything I had ever believed. The more I questioned, the more the old structures eroded beneath me. I lost my balance, my center.

At this point I can not say which came first, my disillusionment with traditional science or my conversion (the only word that aptly describes it) to the new science of chaos and complexity. I remember this period as a time of personal crisis: growing disillusionment and confusion, desiring equilibrium. Yet it was not unpleasant! As much turmoil as I felt for the next year and a half, I remember this time as being one of the most intense periods of positive growth I have ever

experienced. In spite of feeling uncentered and unseated, I was not frightened. It was an exhilarating time of extreme pleasure, ending in personal fulfillment and a sense of peace I had never before experienced. It was like a carnival ride. I felt like a car speeding through a dark swirling vortex with an unknown goal, stopping mere moments later at a scene of instantaneous calm. Arriving at my destination, I was unsure where I had landed. The familiar now looked different. I sensed a peacefulness I had never before experienced; a sense of rightness, and complete belonging. I knew the ride was over, and I was not unhappy, but I felt a need to make sense of the *new* world into which I had plunged. Another semester and another class helped me to see that I had indeed landed in a *new* world – one unfettered by the bonds of modernism. I discovered postmodernism.

I feel a disclaimer is necessary. I do not suggest that everything we have learned from traditional science should be tossed out. Traditional science plays an important part in making sense of the universe, for the sake of convenience if nothing else. It is convenient to know it is 10:00 A.M. Central Standard Time. Clocks facilitate. However, we must add to this knowledge that a minute isn't always a minute; time is *relative* to the experience. Would the Newtonian universe allow time to stand still, or fly by? Yet, we have all experienced this. It is real. Our sense of time is elastic. In spite of its powerful tools and conveniences, the limitations of modernistic science prevent us from asking important questions that also need answers. The field of medical science offers many examples. Through traditional science, we know a great deal about the cellular structure of the human body and the systems that make it work. Modern science found treatments that cure disease and

prolong life. We must, at the same time, recognize and admit that traditional science will not ever have all the answers to physical health. Health is an holistic state of being. It is dependent on attitude and motivation as much as it is dependent on vitamins and genetics. An individual's personal health is a complex interrelationship that includes everything from microbes to nuclear test ban treaties - many things over which no individual, or scientist, has control.

If we are to more fully understand the universe, we need an*other* way to understand it. Postmodernism challenges us to ask questions that have not been, or can not be, answered by modernism; not to replace everything we have, but to create a more inclusive vision. Chaos and complexity theories offer metaphors that might allow us to find new understanding. Gleick (1988) tells how the tenets of chaos theory developed quite by accident, as lone scientists in various fields journeyed beyond the limits of study required by Newton's model. Newtonian scientists and mathematicians shied away from pursuing questions for which no answers seemed possible. Scientists, like everyone, have to make a living. Scientists must work on solvable problems in order to get published, find funding for research, or receive appointments to major universities. Our system does not offer financial rewards to people who study hard questions with elusive answers. In spite of that, a handful of trailblazers worked relentlessly throughout the last century, pushing the limits of the old science in order to answer simple questions that defied solution. These pioneers gave birth to the new science of chaos.

Beginning with the complex, though largely ignored, mathematics of Jules Henri Poincare at the end of the nineteenth century, and followed by the development

of the theory of relativity and quantum physics in the early days of the twentieth century, scientists in many fields have begun to recognize the complexity of the simple, and the importance of *relationship* in maintaining complex systems. It is ironic and perhaps unfortunate that the word *chaos* evokes negative images of confusion and disorder. Periods of turbulence abound in the universe, and chaos theory recognizes, and even celebrates them. This view directly opposes Newton's orderly vision of a rhythmically ticking clock. In chaos studies, turbulence is seen as purposeful and acceptable; the creative force that produces the orderly, inclusive, and organic universe in which we live. Infinitely more complex, more unique, and more interesting than the clockwork model described by Newton, the model of chaos is fractal. A contradictory image lying between two dimensions, a fractal is infinite in size while limited in space; holistic and interconnected, yet uniquely identifiable across scale. Within the chaotic world-view, all matter has purpose and power beyond that of a cog in a machine; the universe exists within all, as all exist within the universe. Everything is separate and unique, while being a part of and having influence over everything else. It is a science whose descriptions sound contradictory to a student of Newton. But at the deep, quantum level of scientific examination, it is the contradictions of chaos that knit the universe together. When chaos occurs in the Newtonian universe, it is seen as an aberration - something gone wrong. Chaos theorists however, view periods of turbulence as normal and necessary to our survival. The universe could not have developed without it, and systems that attempt to subdue it, die. Order does not free us from chaos. Rather, it is chaos that brings us

order. From a chaos perspective there are no aberrations or outliers. The universe is all-inclusive, yet bounded. For traditional science, these implications are astounding.

Understanding the postmodern world from a new and unfamiliar focal point requires the use of a unique methodology. When I determined what it was I wished to study, I felt stymied when looking for a methodology which would lend itself to my quest, for indeed a quest it had become. Then I came across Clark Moustakas (1990) and his description of heuristic research. Suddenly my study began to take form. By developing a heuristic study epistemologically based on my own tacit knowledge, I would be free to immerse myself in the exploration of my school's landscape, replacing the lenses of modernism and Newtonian science with those of postmodernism and the new sciences of chaos and complexity. Like Lewis and Clark, my quest was to enter this unexplored territory of my school and send back vivid descriptions of what I observed, discovered, and discerned.

Need For the Study

Endeavoring to embrace the tenets of the new science of chaos and complexity, it was clear to me that considerable contemplation and scrutiny was required before I could make sense of the postmodern world using this new model of reality. It demanded that I look at my world with *new* eyes; to see the familiar as if it were strange. Though I could envision the larger universe from the perspective of the new science, it was substantially more perplexing to ascertain the implications of chaos within the seemingly mundane, yet ever-changing activities that propelled me through my day. This study was a limited attempt to address my quandary, by examining the tenets of chaos and complexity theory as they applied to one facet of

my life. As a public high school teacher, I was anxious to understand how the system of public education might be observed from the point of view of this new science. My hope was that this study would add something new to the conversation surrounding school reform. If public schools could be understood through the paradigm of chaos, new theoretical explanations and applications might suggest novel resolutions to problems currently vexing educators locally, nationally, and internationally. Indirectly, this study was as much a testimony to the power of paradigms on personal reality as it was a study of the applications of chaos theory in educational reform. To see an *old* world with *new* eyes is a formidable task. It is likewise a quest that might produce data not eagerly embraced. As James Gleick (1988) explained, "Shallow ideas can be assimilated; ideas that require people to reorganize their picture of the world provoke hostility" (p. 38). With this in mind, I offer the following study, not as *the* way but as an *other* way of viewing public schooling.

Maintaining our present course in American public education suggests a future with little noticeable improvement. If it is our intention to create more effective educational practices, we must begin by viewing public education from a different perspective. The effectiveness of our modernist metaphors is slowly eroding under the pressures of postmodern realities. Twenty-first century systems can no longer limp along, hobbled by fifteenth century rationality. Educators must rip off the blinders imposed by modernist science and look upon education with postmodern insight presented by unique metaphors coming from the dynamic *new* sciences of chaos and complexity. Likewise, educational researchers must throw off the chains of

research methodologies that continue to propagate modernist solutions and risk learning something new about educational practice.

Mechanistic, Newtonian metaphors structure our very thoughts about the world we see and understand. Western societies have long studied public school systems using the capitalistic factory model to metaphorically describe both the function and dynamics of schools and learning. Viewing this system as we attempt to view the weather, mechanically - via satellite, we could describe an operation similar to the factory production model of the nineteenth century. Using this metaphor, the *business* of education is to *produce* capable and competent *products*. Typically, the *raw material* clambers aboard the conveyor belt at the approximate age of five and if nothing goes too wrong in production, a *product*-ive citizen is spit out the end after 13 years, ready to enhance society with their skills and knowledge. In this metaphor, education is largely seen as something others do *to* you analogous to filling passive, empty containers. Those atop the powerful hierarchy decide what material is best funneled into the products and the assemblers along the line see to it that each product gets its fair share of the *right stuff*. Supervisors maintain the quality of the *prod*-uction, by overseeing the factory whistles, and the procedures of testing/measuring/evaluating – quality *control*. Indeed, from a satellite perspective, this is what schools appear to be. However, like the weather, schools are dynamic systems. Though you may observe a particular type of weather pattern from a camera in space, on closer inspection, like looking out your own window, you find fluctuations that belie the pattern seen

from space. What appears to be reality, on closer inspection, is not. Rather than easily predictable, weather is not predictable at all. When reformers envision schools from a distant perspective, they defeat their purpose from the outset.

Clearly the factory model persists. Many of the reforms enacted in the past 20 years point to factory model paradigms. Curriculum reforms, i.e. adding more math and science, increasing graduation credits, raising the bar, do not re-*form* the factory, they simply change the formula for the material poured into the passive receptacles on the assembly line. Teachers simply make alterations in the *what* of their teaching; instead of saying *this*, they say *that*. In an assembly line metaphor, the assembler's work is mechanical. They are interchangeable cogs in the machine, unskilled and easily replaced. It is this model that leads people to believe virtually anyone can teach. Higher educational standards and competency testing for teachers are typical of factory-based reform. Comparing test scores is the work of the factory owners. Test scores determine how their products compare to those of other factories. In fact, everything within the factory metaphor is easily quantifiable, ACT/SAT scores, class size, teacher pay, the costs of production ...virtually every aspect of the factory has been counted and beset with control. Yet, schools are a mess and no one seems to know why. With all this *re*forming you would think the schools today would be very different in *form* from the schools of our grandparents. Not so! Schools have changed very little. Perhaps the problem has been that the linear, factory metaphor ignores the complexity and unpredictability of the real classroom.

Capra (1996) explains that there have been two competing traditions in Western science and philosophy: one seeks *substance*, while the other seeks *form*. Those who see the universe as a study of *substance* look to its structure: What is it made of? How do we weigh and measure it? How do we quantify it? For too long educational reformers have focused their questions on substance. Contrast these questions with the questions posed by those who study the *form* of the universe: What is its pattern? How do we map its relationships? How do we qualify it? Capra argues that it is the synthesis of these two traditions that give us a comprehensive understanding of the universe. "What is destroyed when a living organism is dissected is its pattern. The components are still there, but the configuration of relationships among them - the pattern - is destroyed, and thus the organism dies" (p. 81).

Focusing on mechanical rather than organic metaphors, reformers have examined the substantive structure of schools. The patterns have not just been neglected, they have barely been acknowledged. It is time we understand school systems *both* structurally and in terms of pattern. By viewing a public school through metaphors suggested by the tenets of the new sciences of chaos and complexity, problems facing schools might be newly perceived. Perhaps, these new perceptions will not only aid in our understanding of the dynamics of schools and learning, but give us a new perspective from which to re-form schools. The metaphoric tenets of chaos and complexity theory may help us develop new solutions to the problems facing schools locally, nationally and internationally.

As battles rage over the acceptability of quantitative versus qualitative educational research designs, time is lost and information that might help us to better

understand our schools is sacrificed. As educators, we no longer have the luxury of time. The schools are in crisis. Understandings and solutions must be found. The tools we once used made sense of the modern world, but those tools are failing to make sense of the postmodern world. When I discovered the heuristic research method introduced by Clark Moustakas (1990) and its epistemological basis, tacit knowledge, as described by Michael Polanyi (1969) the formulation of this study was crystallized. "In heuristics, an unshakable connection exists between what is out there...and what is within me" (Moustakas, 1990, p.12). I began this study because I felt compelled to answer the call of something that is out there. By selecting the heuristic research design, I have chosen to explore what is out there using the resources within myself; observations, feelings, senses, intuition. By doing this I must accept the validity of any avenue down which I am drawn in pursuit of my quest. Even though there are studies in the field of education that rely on the application of chaos and complexity tenets, my review of the literature has not unearthed an heuristic study that describes a school in terms of the new sciences, holistically, from an individual teacher's viewpoint. In this regard my study is unique.

Research Question

According to Moustakas (1990),"All heuristic inquiry begins with the internal search to discover...a fundamental truth regarding the meaning and essence on one's own experience and that of others" (p. 40). "To see a problem is to see something hidden that may yet be accessible...It is an engrossing possession of incipient knowledge which passionately strives to validate itself. Such is the heuristic power of a problem" (Polanyi, 1969, p.131-132). In the heuristic design, Moustakas believes

the research question must grow out of the researcher's personal excitement and curiosity. During the formulation of the question it is often difficult to clearly view a specific and manageable question because as the theme develops, myriad related elements also come into focus. This process is essential however in eventually narrowing the question to one that is simple, concrete, specific and clearly reflects the intent of the researcher. Moustakas specifies five characteristics that a heuristic research question should include:

> (1) It seeks to reveal more fully the essence or meaning of a phenomenon of human experience. (2) It seeks to discover the qualitative aspects, rather than quantitative dimensions, of the phenomenon. (3) It engages one's total self and evokes a personal and passionate involvement and active participation in the process. (4) It does not seek to predict or to determine causal relationships. (5) It is illuminated through careful descriptions, illustrations, metaphors, poetry, dialogue, and other creative renderings rather than by measurements, ratings or scores. (p. 42)

Through a process similar to brainstorming, ideas related to the general area of interest are generated and then classified into subthemes. The researcher then eliminates subthemes that imply causal relationships or inherent assumptions. The remaining subthemes are then thoughtfully reconsidered, rearranged, or reclassified until a clear and precise question is developed that addresses the specific interest of the researcher.

In following Moustakas' (1990) model I developed the following research question. *What is the experience of* seeing *a public high school through the metaphors of the new science of complexity?* First, this question sought to more fully reveal the human experience of seeing the world through a new paradigm. Second, it followed a qualitative perspective of what it would be like to *be in this paradigm* subjectively, not objectively. Third, it was a question of my personal quest evoking my own personal, passionate and active participation. Fourth, this question did not seek causal relationships. Fifth, I sought an answer that was not quantitatively measured, rated, or scored. With this question as my focal point, I was set to follow Moustakas' advice to "...strive to be humble and not hold a single presupposition, so as to be in a position to learn more" (p. 43). This was my biggest challenge.

Limitations and Delimitations

According to Rosenau (1991) postmodernists seek indeterminancy, diversity and difference rather than synthesis. "They look to the unique rather than to the general, to the intertextual relations rather than causality, and to the unrepeatable rather than to the re–occurring, the habitual, or the routine" (p. 8). In this regard, from the outset, I must state that my intention was to produce a unique and personal description of a personal journey in discovery. Though others might follow my design, in no way could this study be replicated. Likewise, by seeking personal enlightenment, I did not anticipate concluding this paper with the generation of new theories, a list of cause/effect relationships, or prescriptive solutions to problems. Though I hoped that this study would add to the conversation about schools, I didn't

believe the dynamics apparent in one school were necessarily the same in another. However, useful metaphors might be suggested.

I wish I could say that I began my quest with no set limits, and I went wherever my tacit intuition led me. However, like most students, I found myself limited by time, money and circumstance. However, I also believed that the true challenge of this quest was how far and how frequently I could travel within my own tacit self, for that was where my answers would ultimately lie. I was not sure yet where my explorations would lead me. I intended to start my observations in the public high school in which I have taught for the past 22 years; a medium sized high school in a town of 100,000 people in the southwest section of the United States. I planned to gather and record data primarily from within my own resources, i.e. observations, insights, feelings, epiphanies, etc. However, I would include interviews with others adults (18 years and older) who had experienced this or other public high schools from a variety of positions. I hoped these individuals could act as co-researchers. That is they would participate equally with me in the initial collection and interpretation of data. I would be limited in finding people within the school who already had experience with the new sciences or people who were willing to learn enough about the new sciences to be able to find and interpret examples needed for the study. Because of the reliance on personal experience and insight, this was not a study that could be replicated with just any volunteer.

Definitions of Terms

Because there are inconsistencies in meaning within the literature of certain terms used throughout this paper, I offer the following definitions as those that most

closely reflect the meaning I intend. Many of these terms are impossible to concisely define. Most of these terms are included and explicated to a greater degree in the literature review of Chapter 2 or in the methodology description in Chapter 3. However, for the purpose of providing the reader with brief, working definition I have selected the following.

Heuristic Research

In this study heuristic research refers to a qualitative research design developed and formalized by Clark Moustakas (1990) in his book: Heuristic Research: Design, Methodology, and Applications. Epistemologically based on tacit knowledge, as described by Polanyi (1962, 1964, 1966), the heuristic researcher passes through six phases as the research unfolds: initial engagement, immersion, incubation, illumination, explication, and creative synthesis. Ultimately the researcher arrives at and communicates the essence of the experiences studied.

New Science, Chaos/Complexity Theory, Science of Complexity

These terms will be used interchangeably throughout this work. They describe self-organized, interconnected and interdependent systems that are explained using nonlinear mathematical formulations. Often they rely in part on high-speed computers to solve and model complex, nonlinear patterns of interconnectedness. According to Capra (1996), there is no definitive name for this new mathematical expression of complex systems. It is referred to by the terms listed above as well as by the following: mathematics of complexity, dynamical systems, theory, systems dynamics, complex dynamics, or nonlinear dynamics.

Postmodernism

There is no definitive explanation of postmodernism. After reviewing many definitions, what follows is simply a reflection of what I mean when I refer to postmodernism. Skeptical of grand narratives and generalized conclusions, postmodernism avoids the search for a universal, one-size-fits-all *Truth*. Instead, focusing on local, unique experience, postmodernism flows from multiple perspectives. Though it does not replace or revise modernism, postmodernism is the *process of moving beyond* the modern, rational world-view to a destination not yet known.

Tacit Knowledge

According to Polanyi (1969) all knowledge begins with tacit knowledge. When we recognize a specific individual's face, though we may not be able to explain *how* we identified the person, we know it is *that* person. This knowledge that we possess, but can not express is tacit knowledge. It is something known *im*plicitly rather than *ex*plicitly. Tacit knowing does not occur at the conscious level awareness. Intuition is the bridge that joins tacit to explicit knowing. According to Moustakas (1990), "When we curtail the tacit in research, we limit possibilities for knowing...the tacit dimension underlies and precedes intuition and guides the researcher into untapped directions and sources of meaning" (p. 22).

Summary

In this chapter, I recounted the events leading to my decision to undertake this particular study. Explicating the necessity for inquiries into this field, I then followed

Moustakas' instructions for formulating my research question: What is the experience of *seeing* a public high school through the metaphors of the new science of complexity? By characterizing both the limitations and delimitations of this study, I set the bounds within which I will operate. Lastly, I defined important terms used in this study in order to prevent misunderstanding in an endeavor to precisely communicate meaning.

Chapter 2

This chapter focuses on a review of the literature necessary to fully develop a background for understanding the following research question: *What is the experience of* seeing *a public high school through the metaphors of the new science of complexity?* In order to provide a broad base for understanding the multitude of issues involved in this study I will concentrate this review on four areas. First, I will discuss whether metaphors of the new sciences should be applied to education. Next, I will review studies in the literature that have applied the new science to education. Following this, I will describe tacit knowledge as it relates to this study's heuristic design. Finally, I will explain how a postmodern world-view lends itself to this holistic quest.

The New Sciences, Chaos and Complexity Theory

Should Metaphors of the New Science Be Applied To Education?

The tenets of the new sciences have spread throughout the natural sciences during the past 40 years. One can easily find applications of chaos/complexity studies in such diverse fields as meteorology, nursing, physiology, and biology. However, within the past 15 years there has been a growing movement among the social sciences to apply new science interpretations to questions in economics, psychology, sociology, management, and education. Though the interest of many social scientists has been piqued, there are those who find the application of new science tenets to the social sciences unacceptable.

> For many, chaos theory already belongs among the greatest achievements in the natural sciences in this century.... we even hear of changing images of

> reality or of a revolution in the natural sciences.... Chaos theory, too, is occasionally in danger of being overtaxed by being associated with everything that can be even superficially related to the concept of chaos. (Peitgen, 1993, p. 35)

Benson and Hunter (1993) challenge the use of chaos theory in teacher education. From their viewpoint, the methods and criteria developed for the physical sciences cannot be applied to human behavior. They believe these tenets were developed for the purpose of describing physical elements and structures. Human thoughts and emotions are different altogether. Physical elements have no choice in following a strange attractor; human beings make a choice. Though they make a strong argument, one wonders why there is a need to have a *separate* way of understanding human behavior. If humans are related to the rest of the physical universe, human behavior cannot be an aberration to the laws that govern everything else in that universe. Humans are *a part of* the universe and not visitors to it. We cannot have one understanding of the universe, and another distinctly different understanding of human behavior. Smith (1995) points out that social scientists have always had to prove themselves as scientists. Objecting to the application of chaos theory metaphors to social sciences is simply another in a long line of *hard science* arguments against *soft science* applications. According to Fleener (2002), "The over-emphasis on individual rationality, certainty, universal truth, and social progress has created a blindness or disequilibrium that worships scientific rationality over all other forms of reason" (p. 45). Comparing the *soft science* sociology to *the hard science* of meteorology, Smith (1995) says:

> When sociology failed to predict the collapse of Marxism as a world religion, this was taken as evidence of sociology's "soft science" status. When meteorology failed to predict the Bangladesh Cyclone ...this was taken as evidence of how "hard" the science of meteorology really is. (p. 38)

Cutright (1999) points out that one of the difficulties in justifying the use of new science metaphors in the social sciences has been the difficulty of documenting these characteristics within the framework of a quantification methodology. However, he argues that we rely on metaphors to understand organizations. Currently, Newtonian/mechanical metaphors dominate our way of viewing organizations; they are the *default*. Without the option of another metaphoric framework we "are almost certain to consider organizations heavily or exclusively within machine-similar frameworks, with the attendant strengths and weaknesses of those metaphors" (p. 5).

As Dowson, et al. (1999) point out "Schools, and the events surrounding them, act in chaotic ways and this dynamism is not always factored into the academic discourse regarding schools and students" (p. 27). The problem has been that from a quantitative and mechanistic framework, it is inconvenient to address the *aberrations* within schools, even though we develop an incomplete picture by ignoring them. They posit that present methods, both qualitative and quantitative, "give snapshot views of dynamic systems. These snapshots are relatively easy to analyse (sic), but ignore the drama of a 'motion picture' view..." (p. 28). Feigenbaum (1993) reports that traditional scientists use statistical methods in order "to reduce the number of details that one must measure, specify, compute, whatever" (p. 45). In so doing,

details beyond the bounds of the bell curve are ignored. Chen (1998) believes that "reductionist models tend to destroy the very nature of scientific inquiry by attempting to simplify it" (p. 4). By focusing on a distinct *part* of a complex system, the context in which the *part* is embedded is overlooked. Furthermore, Chen states that reductionist methodologies assume "everything has a defined nature, that events are fully predictable and predetermined, and that an event can be considered separately from the agent of that event" (p. 5). Gleick (1993) concurs. "Traditionally, science looked for a more conventional order in nature and treated the erratic as a side issue, an unpredictable and therefore unimportant kind of marginalia. Not any more" (p. 123). He sees chaos as *antireductionist*. It calls for all information to be considered, aberration as well as run-of-the-mill.

Complex systems must be explained by laws focusing on holistic understanding. As Polkinghorne (1993) argues:

> Chaos theory presents us with the possibility of a metaphysically attractive option of openness, a causal grid which delineates an envelope of possibility (it is not the case that anything can happen, but many things can), within which there remains room for manoeuvre (sic). How that manoeuvre (sic) is executed will depend upon other organizing principles active in the situation, viewed holistically (p. 111).

Finally, it is important to remember that in no way are these arguments entirely new. In tracing the development of the logic of modernism, Fleener (2002) suggests that "the logic of domination inherent in modern science and mathematics has created an environment that is not only sexist and racist, but also damaging to our

natural environment" (p. 45). Furthermore, from the time of the scientific revolution attempts to discredit the validity of subjective reasoning have been ongoing. It is conceivable that embracing the metaphors of the new sciences threatens the hegemony of both modern empiricism and those who benefit most by its tenets. Harvey and Reed (1996) point out that positivists have difficulty explaining "why chaos scholars reject the classical paradigm of Newtonian science, and actually seek the company of humanists when exploring the full implications of the new science of chaos" (p. 296). As Smith (1995) opines, "one suspects that repeatedly questioning the 'scientific' status of the social sciences distracts investigators from considering the qualitative nature of nonsocial sciences. Likewise, within utterly numerical realms, complexity theory informs us that quantitative predictions may only be chimerical" (p. 39).

There must be a balance. If we are to fully understand ourselves and our place in the universe, we must find a science *system* that joins reductionism and holism. As Chen (1998) points out, eventually a *system* will reach "a balance between chaos and order, between stagnation and anarchy" (p. 9). Kiel and Elliot (1996) posit:

> The gap between the two sciences may have largely been artificial. As natural scientists more intensively investigate complex natural phenomena, they too must contend with the challenges that have long served to keep the social sciences in the position of a scientific stepchild. Chaos theory seems to represent a promising means for the convergence of the sciences that will serve to enhance understanding of both natural and social phenomena. (p. 3)

Recent Research Applications in Education:

Understanding education through the metaphors of chaos and complexity has evoked considerable discussion. In reviewing the literature however, I found relatively few studies that had actually applied these metaphors to schools. I found only one study that was in any way similar to the one I was attempting to conduct. The following studies were selected for review because they are representative of a broad spectrum of applications of chaos theory in education.

Many studies that utilize chaos metaphors focus on school administration issues. Sullivan (1994) and Gunter (1995) focused on educational leadership and found that by using the tenets of chaos theory, leaders could better understand the dynamics of change, thus enabling them to better lead others within a dynamic, self-organized school. Wertheimer, et al. (1997, 1998) described a chaos-based conceptual model for school reform developed as a result of a study involving changes instituted in an urban school district. In a quantitative attempt to generate a mathematical model to represent and explain this change the researchers suggest that their application is "more than metaphor and less than mathematical model" (p. 103). Akbaba (1999) studied chaotic episodes among three elementary principles and found that new science metaphors can help school leaders recognize and adapt to change.

There are studies that use chaos tenets to explain individual behavior. Guess and Sailor (1993) applying chaos theory to the field of developmental disabilities in special education found several instances in which inappropriate behaviors could be reinterpreted using the metaphors of chaos. They called for further study and application in this field. Chen (1998) applied the metaphors of the new sciences to

psychology in general and psychotherapy in particular. Though not strictly the field of education, the study has intriguing implications for educators. This paper developed the notion that chaos theories, associated with a postmodern world-view, stand in contrast to positivist methodologies. By viewing individuals holistically, and envisioning them as people with problems in adapting to new situations rather than people with disorders, therapists might find more success. Dowson, et al. (1999) explored student motivation in terms of chaos theory and found that these metaphors helped increase understanding of the dynamics of motivation, especially when combined with goal theories. In addition, they assert "phenomena evident in dynamic physical systems may be replicated, both empirically and metaphorically within psychological systems" (p. 28).

Reilly (1999), pointing out that educational reform is really a global issue, looked at the differences in educational reform efforts in Europe. Noted were considerable differences in the initial conditions of the educational systems in each country. Predictably, the outcomes of reform measures instituted were quite different. The most extreme differences were found between Eastern and Western European countries, due to profoundly different initial conditions. Because of the butterfly effect, it was suggested that there would not be a one-size-fits-all solution to school reform. Instead, by using nonlinear models, more successful strategies might be adopted.

Cutright (1999) proposed a prescription for strategic planning for higher learning institutions consistent with chaos metaphors. Emphasizing that this plan in *general* is applicable to an institution's *general* planning, due to the nature of chaos, it

cannot offer or predict *specific* success. However, he believes that additional qualitative studies would add dimension to his findings.

Of the studies I reviewed only one came close to the one I undertook. Livingston, et al. (1998) viewed two quality elementary schools through the lens of chaos theory. Using a list of five characteristics shared by chaotic systems as the primary metaphors used for gathering data, this team studied two elementary schools looking for patterns and themes. The researchers found that, "chaos theory has promise as a different lens for viewing, describing and understanding schools" (p. 16).

Tenets of the New Sciences:

Rather than including descriptions of the individual tenets of the new sciences specifically used or referred to in this study at this time, I instead described them as they were encountered in reporting the results of the study in chapter four. It was my hope that by including them within the context of the results of the study itself, the reader would more clearly understand both the individual tenets and their relation to the study. Likewise, defining these *parts* within the context of the *whole* of the study is faithful to both the research methodology used and the postmodern intent of this study.

Tacit Learning

"If we remove ourselves from that which is known, we lose sense of that which is meaningful. We cannot separate the meaning of things from discovering our own meaning" (Fleener, 2002, p. 27). The credibility of heuristic research comes from the epistemological basis of tacit knowledge. In order to understand the power

of heuristic methodology, it is important to first understand the power of tacit knowledge as described by Michael Polanyi (1969). Trained in medicine and theoretical chemistry in Hungary during the early part of the twentieth century. Polanyi turned his attention to philosophy after World War II, focusing first on economics and later primarily on epistemological issues. Serving in academic positions from Oxford and Manchester in Britain, to Stanford, Duke and Yale in the United States, Polanyi's work has influenced a broad range of scholars in the fields of science, social science, education, literature and theology. Polanyi's work in the field of tacit knowledge influenced and later became the epistemological basis for Clark Moustakas' (1990) development of the heuristic research method.

Trained in the science of modernism, Polanyi, nonetheless, saw inadequacy and hypocrisy in purely rationalistic thought:

> Kant, so powerfully bent on strictly determining the rules of pure reason, occasionally admitted that into all acts of judgment there enters, and must enter, a personal decision that cannot be accounted for by any rules. ...One may wonder how a critique of pure reason could accept the operations of such a powerful mental agency, exempt from any analysis, and make no more than a few scattered references to it. And one may wonder too that generations of scholars have left such an ultimate submission of reason to unaccountable decisions unchallenged. (Polanyi, 1969, p.105-6)

According to Gill (2000), Michael Polanyi's work fits comfortably within the realm of postmodernism, though Polanyi referred to his work as postcritical. Polanyi differs from postmodernists who seek to deconstruct modernism. Instead, he sought

to *re*construct modernism, by "locating an entirely different point of departure, or cognitive axis, for epistemological inquiry. He set aside the 'cult of objectivity' without setting aside the possibility of a need for criteria of meaning and evaluation in our search for human knowledge." (p. 29)

Polanyi believed the epistemology of modernism forces us to choose between dualistic realities: objectivity or subjectivity, mind or body, grounding or relativism, knowable or unknowable. Polanyi challenged this dilemma by changing the grounding metaphor of *foundation* to one of *axis*. By grounding knowledge on an axis, stability was assured, but additional dimensions of knowledge were revealed. Likewise, continuums of dualistic thinking become circular, rather than linear. In this way knowledge becomes both broader and deeper. As Gill (2000) sees it:

> The notion of a center, or axis, of knowing is crucial to a fresh and productive approach to epistemology because it allows for knowing to be grounded or integrated without the necessity of an immovable foundation. One can always ask what it is that holds up any given foundation, ad infinitum. However, an axis needs no support or justification other than itself. (p. 8)

As seen from this perspective, Polanyi envisioned tacit knowledge to be the center of the axis onto which explicit knowledge was tied. Rather than serving as the basis or foundation for explicit knowledge, tacit knowledge is integrated and in relationship to it.

Gill (2000) describes Polanyi's view of an individual's experience as being composed of three integrated, interpenetrating, interacting, multileveled dimensions. The hierarchical, asymmetrical and unidirectional pattern of each dimension ranges

from the physical, social, aesthetic, moral, intellectual to the spiritual. The first of these is the awareness dimension. When we read, we experience several levels of awareness. When reading we may focus (focal awareness) on comprehending. We may, at the same time, be aware that the writing is in English or aware that our eye muscles are directing the tracking of our eyes, but we are not focusing on that aspect of our reading (subsidiary awareness). If we shift focus to the movement of our eye muscles, comprehension becomes subsidiary or disappears altogether. Always, we attend *from* subsidiary awareness *to* focal awareness. In this way awareness is mediated. This vector of awareness is a continuum that runs in only one direction, but is relative in that we can shift in and out of focal awareness.

When the world presents itself to an individual, it is not as a simple, one dimension, but as a multileveled dimension made up of ever richer and more comprehensive levels than the one through which it is mediated. Usually, awareness begins with the richest level. For example, in the case of reading, the text is comprehended before the reader is noticeably aware of the particular sentence structures or vocabulary. Comprehension, the richer level, emerges from the sentence structures and vocabulary, and it can never transcend these subsidiary factors entirely. We look *through* the words *to* their meaning. Neither can the meaning of the *whole* be reduced to its individual subsidiary *parts*. In this sense, comprehension (focal awareness) is bounded by the sentence structure and vocabulary (subsidiary awareness), and cannot exist without them. Likewise, the subsidiary parts, while understood individually, would not provide a holistic meaning. For Gill (2000),

> To exist within simultaneously interpenetrating dimensions is to be aware of and participate in more than a single aspect of experience at once, while meaning itself can be viewed as inextricably bound up with perceptual factors without being reducible to them. The dancer and the dance are inseparable, but neither is simply a function of the other, nor are they the same entity. (p. 34)

If the awareness dimension functions as the input of experience, then the activity dimension functions as the output. Just as all human awareness comes from the subsidiary to the focal, all human activity begins from the bodily pole and moves to the conceptual. Gill (2000) uses the example of language development to exemplify this relationship. Though speech and language are highly abstract, they never cease to involve physical processes. These physical processes become second nature to us and though we often fail to appreciate their significance, they don't disappear. In this way, Polanyi (1964) eliminates the mind-body dualism of modernism, and integrates the relationship of body to mind:

> Dwelling in our body clearly enables us to attend *from* it to things outside, while an external observer will tend to look *at* things happening in the body, seeing it as an object or as a machine. He will miss the meaning these events have for the person dwelling in the body and fail to share the experience the person has of his body. Again we have loss of meaning by alienation and another glimpse of the meaning of dualism...Interiorization bestows meaning, alienation strips meaning. (p. 148)

This difference between the notion of the *embodiment of the mind* as opposed to *the mind inhabiting* cannot be overstated. Gill (2000) points out:

> A person's body is the only physical object in the universe from which he or she cannot walk away. Moreover, our relationship to our own body...is entirely different from our relationship to other physical bodies. ...when we scratch our own itch...we act as both subject and object of the same activity...our bodies are both in the world as physical objects and the means by which we come to know the world through interaction with it. Of no other aspect of reality is this true. (p. 45)

According to Gill (2000), Polanyi does not view sensory input as passive, nor do individuals respond blindly to sensory stimuli. Rather, the senses all interact symbiotically, together with the mind, often at lightening speed. This can clearly be observed watching someone operate a video game. If that person is carrying on a conversation with you at the same time, it is hard to believe there is not a symbiotic interaction. This is quite different from modern philosophy's approach of analyzing sensory experiences independently of one another.

We learn by doing. That is the relationship between awareness and activity. According to Polanyi (1964),

> By watching the master and emulating his efforts in the presence of his example, the apprentice unconsciously picks up the rules of the art, including those which are not explicitly known to the master himself. These hidden rules can be assimilated only by a person who surrenders himself to that extent uncritically to the imitation of another. (p. 53)

The interaction of the subsidiary and bodily awareness produces integration. Parts are integrated into wholes. For example, in learning to drive a car, many *parts* must be learned (acceleration, braking, judgments, traffic laws), before the *whole* process of driving is integrated. Integration is not reversible. Driving a car can not be unlearned. The skill may deteriorate without practice, but it cannot be unlearned. In such a case, *indwelling* has occurred. The mind, and all the senses work together often with repeated practice until the procedure is virtually automatic. In so doing, the mind is embodied. Though the mind is at work in the process, it is not possible to articulate every nuance of the process. This is tacit knowledge. On the other hand, the interaction of the conceptual and focal awareness produces inference. Inference may be either inductive or deductive, and it is reversible. One can move from the evidence to the conclusion or from the conclusion to the evidence. This is *knowledge* known in the modern sense. It is explicit. It can be articulated. Inference cannot be accomplished without a foundation of integration. Polanyi's third dimension is that of cognitivity. Intersecting awareness and activity, it consists of a continuum ranging from tacit to explicit knowing. In this way all knowledge is embodied.

> By placing embodied activity at the center of human cognitivity, ...[Polanyi] provided a way to connect the knowing agent and that which is to be known by simply denying the dichotomy before it gets off the ground. ...we are never shut up within our own minds as knowing agents, cut off as it were from the social and physical worlds that surround us. ...The capacities for relationship and cognitive activity are already in place, and they form the framework

within which we function as knowers, even when we do so erroneously. (Gill, 2000, p. 49)

Because tacit knowledge is the tether that ties explicit knowledge to the axis of knowing, and because tacit knowledge falls in the subsidiary vector of awareness, *we always know more than we can articulate*. Though explicit knowing cannot occur without tacit knowing, tacit knowing can exist without explicit knowing. Because tacit knowledge can exist independently from explicit knowledge, there is no way to explicate it. The problem is that we have a hard time justifying unarticulated knowledge in a modernist way, because modernist science systematically ignores it. It is at this point that accusations of subjectivity arise. If tacit knowing cannot be articulated, can it be regarded as reliable and true? Gill (2000) argues:

> The attempt to define knowledge according to modernist requirement seeks to eliminate the possibility of error by removing all personal and valuational aspects from the cognitive enterprise, but this also removes the very conditions that render knowledge a viable and valuable endeavor in the first place. (p. 59)

When our ideas go awry, it is not a bad thing. In fact mistakes are needed in the making of meaning. Gill says "it is of fundamental importance to remember that a 'mistake' is precisely that, a 'mis-take', a failure to get it right. But failure to get it right is only recognizable as such because one already knows what getting it right would mean and be" (p. 59).

Subjectivity remains the major criticism of Polanyi's work. From a modernist point of view, it is unforgivable. However, even the modernists must admit that it is

possible that theories *proven* through stringent, empirical methodologies have not always been *true* either. How objective are empirical studies relying on observations made through human subjective perceptions of sight, sound, and taste. Are empirical statistics that rely upon *subjective* data cleaning *objective*?

Postmodernism

"Although seemingly unrelated, chaos theories affiliate intimately with postmodern epistemology and stand in contrast to modernism" (Chen, 1998, p.13). Just as twenty-first century Romans live among the ruins of their ancient civilization, twenty-first century Americans live among the ruins of a world once dominated by modernism. Ineffective and destructive as it is, modernist philosophy permeates the fundamental institutions of Western society, holding us hostage - unable to throw off the restraints of domination and control. Because of this, we continue to act on the basis of a belief system that no longer serves us, and furthermore robs us of the power to change. As we envision the world of the postmodern era, we step out of the restraints imposed by the modern paradigm, and understand the omnipotent stranglehold that regulates everything within our own lives in particular, and within Western culture in general. The achievements of science and mathematics resulting from modernistic rationalism are impressive. Yet, to recognize how limiting this mindset has been to our understanding ourselves and our place in the universe is disconcerting. Modernism dictates to virtually every institution within our culture. The power and influence of empirical mathematics and a rationalistic science have all but removed *people* from the universe they construe. According to Fleener (2002):

> by removing the observer ... individual experience can be ignored.... With the mathematization of science, the removal of context, and the focus on being, scientific methodology fundamentally changed. Scientific methodology became both empirical/testable and abstract/mathematical. Formal relationships, represented mathematically, could be explored. Mathematics became both the mode of abstraction and the means of predictive calculation and confirmation. Because of the mathematization [sic] of reality, the world, so perceived, and all of nature became quantifiable, predictable and controllable. (p. 40-41)

Scientific method, touted as exacting, replicable, and unbiased, seeks to provide *the universal Truth*. Certainly it provides us with important information, but it has not given us all the answers.

In contrast, proponents of postmodern views are charged with explicating a world free of modernist restraint, while laboring to uncover a universe still blanketed by layers of modernist thought. Postmodernism has taken root, sometimes simultaneously, in many diverse fields. Rather than simplifying the process of understanding postmodernism, to a large degree, this has complicated it. As Fletcher (2000) notes, "The literature on postmodernism has expanded across a wide variety of disciplines beyond the point where it is possible, or at least easy, to find a clear definition" (p. 80). This remark echoes one of the chief criticisms of postmodernism: its elusiveness in terms of standard definition. Postmodernists have difficulty agreeing upon the *correct* spelling of postmodernism (or post modernism, or post-modernism), much less what its *exact* meaning is. But then, postmodernists would

also have difficulty defending the desirability of concepts like *correctness* and *exactness*. Another major obstacle to defining postmodernism is language. Our language is saturated in modernism. Because of this, most definitions of postmodernism describe what it *is not*, rather than what it *is*. In lieu of attempting yet another definition of postmodernism, the following descriptions will help to give some notion as to what postmodernism *is* (and *is not)*.

> *[Postmodernism is] ... made up of theories that are unified in their rejection of the universal or structural in favor of a conceptual and methodological emphasis on difference, multiplicity, and the fragmented nature of experience. (Fletcher, 2000, p. 28)
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> *Postmodernism is also characterized by its distrust of and incredulity toward all 'totalizing' discourses or metanarratives – those large-scale or grand theoretical frameworks that purportedly explain culture, society, human agency, and the like. ...In place of these metaframeworks, postmodern theory endorses heterogeneity, difference, fragmentation, and indeterminancy. (Schwandt, 1997, p.120)
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> *Postmodern thought suggests that the criteria which theories use to establish what is true or false, good or bad, are not universal and objective. They are, rather, internal to the structures of the discourses themselves and thus historical and subject to change. (Weeden, 1997, p. 172)
>
> *In disciplines from architecture to theology, foundations are being shattered. In fact, the concept of foundation, itself, is now challenged. We are entering a new, eclectic, "post" era. In this era, the past will not disappear but will be

reframed continually in the light of an ongoing changing present. ...the post-modern transcends, really transforms, the modern rather than rejects it totally. (Doll, 1993, p.157)

*Those of the modern conviction seek to isolate elements, specify relationships, and formulate a synthesis; post-modernists do the opposite. They offer indeterminancy rather than determinism, diversity rather than unity, difference rather than synthesis, complexity rather than simplification. They look to the unique rather than to the general, to the intertextual relations rather than causality, and to the unrepeatable rather than to the re-occurring, the habitual, or the routine. (Rosenau, 1991, p. 8)

*As an emerging world view, postmodernism acts to complement modernism...Modernism holds that there is a single reality that can be known by a self-contained, individuated knower; whereas postmodernism questions the notion of an essential or core self. Specifically, postmodernists view the self as inextricably embedded in a matrix of others, and 'truth' itself as intersubjective and residing in multiple realities. (Chen,1998, p.13)

It is quite possible postmodernism will never be adequately defined. Definitions are modernist tools. However, postmodernism does not simply replace modernism. There is no new set of rules by which the universe is explained. In many ways postmodernism is a process - the journey rather than the destination. Though Whitehead never used the term postmodern, perhaps he would come closest to understanding it, as Cobb (1993) explains:

> Postmodernism in the Whiteheadian sense requires ...the reconception of the organization of knowledge as a whole. Modernity began by dividing reality into the two worlds of mind and matter...It then proceeded to separate the world into compartments, each of which could be studied in separation from the others. If the world truly were machinelike, this might work...[however]...such bifurcation and fragmentation falsifies reality, that all things are interconnected and that this pattern of relationships is constitutive of the relata. What is said from this perspective cannot be contained within the organization of knowledge based on modern principles. (p.169-170)

Modernism has convinced us of the value of prediction and control. The more empirical information available, the greater the ability to predict and control. Objectivity is honored subjectivity is deplored. From a modernist perspective understanding questions like "Why am I here?" or "What is the meaning and purpose of my life?" or "What does this mean to me?" are simply irrelevant. In my view, this has been the major failure of modernism. Understanding quantifiable facts does not elicit complex, human understanding of the universe. But modernism teaches that the only questions worth asking are the ones we can somehow measure, using scientific/mathematical empirical methods.

In the field of education, these methods have allowed us to count, test, and measure every conceivable part of a school system. Even so, when all the data generated through modernistic methods are collected and analyzed, we still have no understanding of what really motivates students to learn, no *formula* for universal academic proficiency, no *equation* that brings all students the power to live happy

lives. Perhaps it is time to ask questions that can't be quantified and seek answers beyond the bounds of modernism.

If public schools can be understood through methods and metaphors free of the restraints that chain them to the modernistic paradigm, new theoretical applications might be developed to answer the questions students, parents, and educators currently cannot even ask. Perhaps the answers to these questions would help us solve the problems vexing schools and society on local, national, and international levels. Doll (1993) believes it is unclear exactly what the implications of postmodernism will be in education. Conceivably new relationships among the people involved will re-conceptualize curriculum.

> The linear, sequential, easily quantifiable ordering system dominating education today - one focusing on clear beginnings and definite endings - could give way to a more complex, pluralistic, unpredictable system or network... A whole new sense of order emerges; not the symmetrical, simple, sequential order classical science borrowed from medieval thought, but an asymmetrical, chaotic, fractal order we are now beginning to discover in the post-modern science. (p. 3)

Summary

In this chapter I presented a review of the literature I felt would be useful in giving the reader a better understanding of the study I have designed. To answer the research question *What is the experience of* seeing *a public high school through the metaphors of the new science of complexity?* background is needed from several different areas. I have reviewed the pros and cons of applying metaphors of the new

sciences to the study of education. In addition, I have presented a survey of the literature related to educational studies that relied on metaphors developed from the new sciences. Finally, I have presented information about tacit knowledge and postmodernism in order to give the reader some background for understanding of the relevancy of both the intent and methodology of this study.

Chapter 3

In this chapter I will begin by summarizing the need for this study which seeks to answer the research question: *What is the experience of seeing a public high school through the metaphors of the new science of complexity?* I will then briefly summarize how I came to embark on this quest. After explaining the development of the heuristic research method, I will explicate Clark Moustakas' research design. The population of this study will be described and then I will present the procedures I will follow in gathering and analyzing my data. Finally, I will describe the way in which I will present the data in creative synthesis.

Need and Background of the Study

We cannot continue to objectify our schools. Students are more than things under a microscope. The new sciences compel us to develop tools that allow us to describe the world in terms of new metaphors. Though aspects of chaos/complexity theories could be studied using scientific methodology and rationalistic measures, those methods alone can not give us a whole picture. The holistic understanding of a dynamic, complex system, like a school, relies on more than what parts of it can be measured in isolation. Thus, to adequately describe a complex, dynamic system it is necessary to be inclusive of all data, not simply data that can be isolated and easily counted. Different tools of research must be sought and employed. Other ways of knowing must be considered. I suggest that one such investigatory tool already exists: heuristic research. This methodology relies on another way of understanding: tacit knowledge.

The heuristic method described by Moustakas (1990) allows for the holistic collection of data. It engages and employs the researcher's personal attributes of understanding, insight, and interpretation. Specifically, it relies on the tacit knowledge of the individual researcher. The totality of the researcher becomes fully immersed in the study. The topic of the research is studied and interpreted from the axis of tacit knowledge *within* the researcher. There is no pretense of an objective, unbiased observer. Every aspect of the researcher's humanness is called upon and put to use in the form of tacit understanding. As described by Michael Polanyi (1969), tacit knowledge is both difficult to measure and often inexplicable to the individual. Reliance on tacit knowledge requires that the research data filter *through*, and at the same time, become a *part* of the researcher. This method provides an element of personal understanding of a local event that is less a universal truth than a unique individual perception of a moment in time. The heuristic design is very much a personal quest to find personal understanding of the essence of the subject being studied.

Developing a postmodern approach to the study of education is challenging. The heuristic model offers a research tool through which one might approach the development of a new, and postmodern, way to understand education. Attempting to study a school by essentially becoming a part of it also fits nicely with the holistic, relational metaphors created by the new sciences of chaos/complexity.

Heuristic Research Methodology

"Having made a discovery, I shall never see the world again as before. My eyes have become different, I have made myself into a person seeing and thinking

differently. I have crossed the gap, the heuristic gap, which lies between problem and discovery" (Michael Polanyi, 1962, as cited in Moustakas, 1990, p. 56). The word *heuristic* comes from the Greek word *heuriskein* meaning to discover, or to find. A cousin to the word *eureka*, a heuristic researcher is challenged to learn independently from his own investigation. Clark Moustakas introduced the heuristic model of research in 1961 with the publication of his work, Loneliness. Moustakas continued to apply this style of research to subsequent books on loneliness published throughout the 1970s. Stating that he was influenced by the works of Abraham Maslow in the area of self-actualization, as well as Sydney Jourard's studies of self-disclosure, Moustakas continued to refine his model. Extracting kernels of insight from a variety of sources, Moustakas includes within the framework of heuristic methodology Michael Polanyi's work with tacit knowledge. Martin Buber's dialogue and mutuality, Paul Bridgeman's subjective/objective truth, Eugene Gendlin's analysis of meaning and experience, and Carl Rogers' theoretical and conceptual support are also cited by Moustakas as important influences. Eventually, in 1990, Moustakas published the decisive resource for this model: Heuristic Research: Design, Methodology, and Applications. In this book, Moustakas describes heuristic research as: "a process of internal search through which one discovers the nature and meaning of experience...The self of the researcher is present throughout the process and...not only is knowledge extended, but the self of the researcher is illuminated" (p.9-10).

Moustakas (1990) very clearly delineates the stages in this design. The researcher first looks inward to discover the question of his research through a period

of *initial engagement*. Moustakas describes the heuristic research question as having definite characteristics:

> It seeks to reveal more fully the essence or meaning of a phenomenon of human experience. ...It seeks to discover the qualitative acts, rather than quantitative dimensions, of the phenomenon. ...It engages one's total self and evokes a personal and passionate involvement and active participation in the process. It does not seek to predict or to determine causal relationships. ...It is illuminated through careful descriptions, illustrations, metaphors, poetry, dialogue, and other creative renderings rather than by measurements, ratings or scores. (p. 42)

Then begins a stage of intense focus called *immersion*. The researcher draws from any and all experience to gain insight into the question including interactions with: people, places, things, meetings, readings, nature, self, hunches, dreams, intuition, and so on. "The deepest currents of meaning and knowledge take place within the individual through one's senses, perceptions, beliefs and judgments. This requires a passionate, disciplined commitment to remain with a question intensely and continuously until it is illuminated or answered" (Moustakas, 1994, p. 18).

When little new information emerges, it is time to put the data aside and pull back into a period of *incubation*. At this point, tacit knowledge and intuition begin to make connections between the data and the research question in order that the researcher might reach the next stage, *illumination*. This is the breakthrough stage, a period in which new understandings emerge. The essence of this experience is then described in depth by the researcher in an attempt to depict the essence of the

phenomenon. This *explication* stage allows the researcher to envision the question as holistically as possible. Lastly, the researcher attempts to express the findings in a *creative synthesis* of the data. This may result in a narrative depiction and follow traditional models of presentation. Most importantly, Moustakas (1990) encourages the researcher "...to permit ideas, thoughts, feelings, and images to unfold and be expressed naturally. One completes the quest when one has an opportunity to tell one's story to a point of natural closing" (p. 39).

The quest for heuristic *illumination* allows the researcher to develop a personal, interconnected relationship with the subject of study, rather than a *separation* based on detached, disinterested observation. An attempt by a particular individual to find a particular understanding, within a particular place, during a particular period of time is a search for *an* understanding rather than *the* understanding of the phenomenon. In this regard it is postmodern. Though this type of study might be valuable in helping others to understand public schools in a different way, above all, it is important in a personal quest to find personal meaning within a new paradigm. It is subjective – the researcher cannot be stripped away from the research. Perhaps Moustakas (1990) says it best when he states, "I am creating a story that portrays the qualities, meanings and essences of universally unique experiences" (p. 13).

Critics would argue that the subjective quality of this methodology could lead to faulty interpretations. Through a postmodern lens, we might argue whether or not a personal interpretation can be judged *correct* or *incorrect*. However, Gill (2000) suggests that personal interpretations are fluid. They adjust according to the

presentation of new information (just as modernist theories do). We rely not only on our own interpretations, but also on interpretations shared by others. Our relationships with others help us to continually *reassess* our own interpretations. Human beings make mistakes in reasoning. Human beings also have the ability to develop new understanding and greater insight. And when they do it is called wisdom. As Gill puts it:

> It only remains to be said that we are not participating in this dance of cognitivity as individual knowing agents. Rather, the dance must be seen as a common group effort on the part of the entire human community. Thus, we are dancing in a large circle, joined through out respective embodiments, to each other and to the surrounding world. Sometimes we agree on the proper moves to make, and sometimes we do not; sometimes we agree on the nature of reality, and sometimes we do not. But by means of our common dance, we can and do correct our views and come to a knowledge of the world, one another, and even ourselves. (p. 50)

Heuristic research allows for a subjective, personal quest to find personal understanding of the essence of an experience. As such, ontologically, a study using the heuristic design favors a perspective seeking, rather than truth seeking world-view (as described by Langenbach, et al, 1994). Epistemologically, this research method relies on tacit knowledge as described by Michael Polanyi (1969). Tacit knowledge brings a sense of wholeness to understanding the many parts of a subject. Axiologically, a study of this nature is qualitative. As Denizen (1994) points out, "positivist methods are but one way of telling a story about society or the social

world. They may be no better or no worse than any other method; they just tell a different kind of story" (p. 5). Some things that are important to know cannot be known quantitatively. It is only through thoughtfulness, reflection, and illumination that some things can be understood. At this point in time, it is especially crucial in the field of educational research that we understand as much as we possibly can. The heuristic methodology outlined by Moustakas (1990) provides researchers an opportunity to delve more deeply both into themselves, and their research topic in search of the essence of the experience. Dewey (1933) remarked upon the value and validity of an individual's personal reflections when he wrote:

> No one can tell another person in any definite way how he should think, any more than how he ought to breathe or to have his blood circulate. But the various ways in which men do think can be told and can be described in their general features. Some of these ways are better than others...The better way of thinking ...is called reflective thinking: the kind of thinking that consists in turning a subject over in the mind and giving it serious and consecutive consideration. (p. 3)

From an ethical standpoint, validating the findings of a heuristic study may seem problematic, due to the subjectivity of the study and the reliance on the researcher's own experience. In his 1950 book Reflections of a Physicist, Paul Bridgeman argued that:

> The process that I want to call scientific is a process that involves the continual apprehension of meaning, the constant appraisal of significance, accompanied by the running act of checking to be sure that I am doing what I

want to do, and judging correctness or incorrectness. This checking and judging and accepting that together constitutes understanding are done for me by no one else. They are as private as a toothache and without them science is dead. (as cited in Moustakas, 1990, p. 33)

Personal responsibility and integrity on the part of the researcher are indeed imperative in all phases of this type of study. Data collection, interpretation and evaluation must be completed conscientiously, and explained thoroughly. Documentation is crucial in establishing the veracity of the findings in this form of research. Likewise the final presentation must present a reasonable and reliable portrait of the data.

Population

The population for this study consisted of any or all individuals who have had any connection to a public high school in America in the past 20 years. The purpose of this study was to envision a high school as a whole, through the perspective of a new paradigm, the new science of chaos and complexity. In doing a study of such broad dimension, it required looking at people beyond the school itself. For example, the expectations of people within the community and society in general play a role in what a public high school is, as do laws developed by local, state, and national legislators. The majority of Americans have attended public high schools. All these people would be included in the population of this study. I did not intend to focus on any specific gender, or group. Economic group, social class, ethnicity, race, age, experience may be mentioned in examples, however, it was not the purpose of this

study to single out one group from the others. Rather, I hoped to depict a holistic portrait of high school.

The particular high school I began my study with was located in a mid-sized city in the southwest section of the United States. It was the smallest of three city high schools, with a student body of approximately 800. I was assisted by a small group of individuals who had some understanding of the new sciences. Through interviews they helped me to envision many aspects of the high school. I used information from other high schools as well, depending on the experiences cited by my co-researchers.

Procedure

Developing the Research Question

Pursuing this quest by following the stages of discovery outlined in Moustakas' (1990) heuristic model, I first explored my area of interest during the phase of *initial engagement.* Moustakas recommends a process much like brainstorming in which the researcher freely jots down thoughts and ideas related to the area of interest. In my case, this process lasted over a period of months. I began to envision this study in the summer of 2000, while taking courses in postmodern thought and systems theory. However, none of the research designs I had formerly examined appeared to fit the kind of study I had in mind. Then in the fall of 2000, while enrolled in my final research class, I was introduced to the heuristic design. Upon reflection, I recognize that I was in the stage of initial engagement long before I had even heard the term. I already had begun listing thoughts and ideas for possible study. During the spring of 2001, I would revisit and examine the ideas I had listed,

adding to or clarifying ideas to reflect changes evolving from my experiences or reading while I prepared for my general examination.

I followed Moustakas' next steps, without formal awareness of what I had done. By the time I had completed my general exam in the summer of 2001, I had categorized or grouped these concepts, eliminated subthemes that appeared to contain inherent assumptions or causal relationships and finally, shifted and sorted the remaining subthemes until a central topic emerged. I then stated my question in a variety of ways until I felt the wording of the research question adequately reflected the purpose of my quest: *What is the experience of* seeing *a public high school through the metaphors of the new science of complexity?*

This question met the characteristics recommended by Moustakas. First, it sought to more fully reveal a human experience - that of seeing the world through a new paradigm or world-view. Second, it followed a qualitative rather than quantitative perspective. I sought to know what it is like to *be in this paradigm* subjectively, not objectively. Third, this question evoked my own personal, passionate and active participation - it is in fact my personal quest. Fourth, this question did not seek causal relationships. Fifth, I answered this question without the use of quantitative measurement, ratings, and scores.

Institutional Review Board Approval

After settling upon my question and research design, I prepared a rudimentary account of my study and applied to the Institutional Review Board at the University of Oklahoma for permission to begin this study. Institutional Review Board approval was granted in early November of 2001, as I began working on my prospectus.

Methods of Collecting Data: Primary Researcher

As work on my prospectus progressed, I eventually had to develop a plan to guide my quest through the collection and interpretation of data and the eventual explication of findings. I focused first on myself. How would I collect data from my own insights and experiences? I decided that as the primary researcher, I would do three things. First, I would begin keeping a field log that recorded my ideas, insights, dreams, epiphanies, and observations related to this study, as well as daily experiences that I might sense to be important even if I could not say why at the time. I set up a schedule for making entries in my field log. During the week I would try to record entries at the end of every workday. On weekends and holidays I would try to write daily, at approximately the same time in the afternoon, unless that routine could not be accommodated. In that event, I would maintain my writing schedule as much as possible. On weekends I hoped to go back over the earlier entries, and reflect on what I had written during the week, while looking for emerging themes and determining where I should focus attention in the following week. By keeping a notebook or mini tape recorder close at hand I could capture fleeting thoughts that might escape before I could record them in my field log. I moved a pad and pen next to my bed for recording middle-of-the-night epiphanies and waking dreams. These scraps of consciousness would be re-recorded later in the field log for that day.

Self-dialogues were another source of data collection recommended by Moustakas (1990). Similar to conversations one might have with a co-researcher, the primary researcher in this case played the role of interviewer and interviewee. I planned to record these dialogues in my field log. I also considered the possibility of

experimenting with oral, taped dialogues that would be transcribed later. I did not want to set up a particular schedule for self-dialogues, preferring to conduct them when they *seemed* propitious. I decided that it might be beneficial to attempt at least one self-dialogue prior to my first interview. I could decide after the first co-researcher's interview if other self-dialogues would provide insight.

Another type of data I would collect would be documents, artifacts or other pieces of evidence that might seem important to this study. These articles would be collected in a section of my field log, unless they were too large or bulky, in which case I would keep a written reference to them, noting their location.

Methods of Collecting Data: Co-Researchers

Next, I turned my attention to procedures involving my co-researchers. Moustakas (1990) suggested that in theory a heuristic study need only have one participant. However, providing the depiction of others gives a deeper and richer portrait of the experience. Again, the researcher must be the judge as to when enough information has been revealed. In this beginning stage, I envisioned recruiting around ten people to interview. However, relying on my intuition, and guided by tacit knowledge, I hoped to leave this open and unquantified. I hoped to be led to the places I needed to go. I did not want to fix a particular number of people. I hoped to select co-researchers one at a time, as I was drawn to them, so to speak. I also did not want to determine ahead of time particular criteria for selection such as age, sex, or experience. I did determine to limit my study to adults over the age of 18 who had experienced a public high school in the past 20 years. The experience of that person could be in virtually any capacity, including people with any type of public school

employment, former students, parents, and the like. In addition, I needed people with some knowledge of the new sciences, or people who were willing to learn about the new sciences. I believed this knowledge base would be necessary for co-researchers to begin to see the school through the paradigm of the new sciences.

I decided to recruit co-researchers who were representative of the different groups of people that made up the school or if something about their experience seemed of interest or importance to this study. In approaching potential co-researchers I would tell them as much about this study as they wanted to hear. I would explain that if they decided to participate in this project, they would be asked to participate learning activities designed to inform them of the tenets of the new sciences. They would then have a period of time to think about these tenets in terms of their own experiences. Co-researchers would then be interviewed. Interview sessions would last approximately one hour each, sometimes in small groups. These interviews would be audio taped and later transcribed to insure that the information was gathered as accurately as possible. I would explain that there were no foreseeable risks of participation in this project for them personally. They would also be told that their participation could greatly help educators provide solutions to problems facing public high schools. I would explain that conceivably they might gain personal insight from participating in the study by discussing their own observations and theories concerning these issues and concerns.

Participation in this project would be strictly voluntary and refusal to participate would involve no penalty to co-researchers in any way. They would be free to withdraw at any time without penalty as well. All information from this

project, including transcripts of interviews and audiotapes, would be kept in a locked file, and would remain confidential within limits of the law. The records would be destroyed at the conclusion of the investigation. They would be referred to by pseudonyms chosen from fictional characters in literature. Co-researchers could either select their own pseudonyms, or I would choose one for them. Any setting of their experience would be disguised so that real names and locations would not be known. Before participating, each co-researcher would be asked to read and sign a consent form approved by the Institutional Review Board. Co-researchers would receive copies of this signed form, along with phone numbers should they have further questions.

I hoped to conduct interviews at a time convenient to the co-researcher, in a setting that was relaxing to them. Moustakas (1990) points out that informal conversation most closely fits the flow of a heuristic quest. Because of that, I prepared a general list of topics to focus the interview, hoping to refer to it only when the dialogue did not seem to unfold naturally. At some point during the conversation I would also attempt to record basic personal information about participants (educational background, social economic background, ethnicity, occupation, type of public school experience) in the event it became important in the analysis phase of this study. Prior to our meeting, I would ask them to what extent they had studied the new sciences of complexity. It would be necessary for me to explain the tenets of the new sciences in the form of metaphors, in order for the co-researchers to envision their own experiences. It might also be advisable to give the co-researchers some time to think about these metaphors before meeting to discuss them. I determined I would

deal with these issues on an individual basis because I had no firm notions as to who my co-researchers would be or what experiences they may have had. The following list of topics/questions will help me to spark the conversations if they do not smoothly unfold (paraphrased from Moustakas, 1990, p. 48):

*What experience have you had with this particular new science metaphor?

*What qualities or dimensions of the experience stand out?

*What examples are alive or vivid?

*What events, situations, or people are connected with the experience?

*What feelings or thoughts were generated by the experience?

*What bodily states or shifts occurred in bodily presence during the experience?

*What time and space factors affect your awareness and meaning?

*Have you shared all of the significant ingredients of this experience?

Following each interview I will schedule time to record my reflections of the interview and how this information affected me. Later I would transcribe the tape and immerse myself in the themes and qualities expressed. When I could garner no further understanding, the interview would be set aside to incubate and while my tacit powers sorted through it. As illuminations began to glimmer, I would begin to write a depiction of the co-researcher's experience. In the event I might need more information, I would set up a second interview. Once satisfied that I had an accurate portrait of the experience, I would submit a copy of it to the co-researcher and together we would discuss any corrections or clarifications needed. In addition, I

would collect any significant articles or personal documents shared by co-researchers during the course of the study.

Analysis of Data

Following Moustakas' (1990) outline for analysis, first I gathered all data from one source. I immersed myself in it, until I felt confident that I had a complete understanding of it. I then set it aside, to incubate. Later, when illumination unfolded, I returned to the data seeking themes or insights. When I no longer found new themes I ended the collection process. Collecting all of the data, I immersed myself in it. Once again, I pulled away and allowed the information to incubate. Finally, after illumination occurred, I explicated the findings by developing a depiction of the experience. Moustakas (1990) urged the researcher to "be vivid, accurate, alive, clear, and encompass the core meanings of the phenomenon as experienced by the individuals and the group as a whole" (p. 52). At this point I returned to the original data, selecting two or three co-researchers with whom I shared the general portrait of the experience. These co-researchers then suggested additions or corrections to complete and validate the process.

Finally, the last step in this heuristic process was the creative synthesis. The researcher develops "an aesthetic rendition of the themes and essential meanings of the phenomenon. The researcher taps into imaginative and contemplative sources of knowledge and insight in synthesizing the experience" (Moustakas, 1990, p. 52). Because I did not know yet how this study would affect me, or what I would experience in the process, it was difficult to make a commitment to a particular creative synthesis. I was not (or at least I had not yet been) a poet, an artist, or a

musician. My skills as a writer were less than literary. At this very early stage in the study I anticipated a creative synthesis much like a paper I read earlier in my course work. This paper was a master's thesis (Mackie, 1998) that made use of the concept of a *walkabout.* As described by Beresford (1997), a walkabout was an aboriginal custom in Australia whereby an individual, leaves the routine of his life and walks into the desert as part of a spiritual quest. Guided by the spiritual power, the walker focused on a specific site. It was a mindwalk in the sense that it was silent; all that happened occurred in the mind. When the walk ended the walker might have spontaneously emoted some expression concerning the future. Finally, the walker might leave behind some token of the day's work. My hope was to conclude my heuristic study with a narrative depiction of a walkabout focusing on a high school, as seen through the perspective of the new sciences.

Summary

What is the experience of seeing a public high school through the metaphors of the new science of complexity? I began this chapter by summarizing the need for a study that seeks to answer this research question. Then I briefly summarized how this quest developed. After explaining the development of the heuristic research method, Moustakas' research design was explicated. The population of this study was described and I presented my procedures for gathering and analyzing my data. Lastly, my method for presenting the creative synthesis of the data was discussed.

Chapter 4

The purpose of this study is to explore and describe a public high school in terms of the new sciences of chaos and complexity. In this chapter I will briefly review the purpose and methodology of this study aimed at answering the question: *What is the experience of seeing a public high school through the metaphors of the new science of complexity?* I will describe the process of collecting and analyzing my findings using the heuristic process of *initial engagement, immersion, incubation*, and *illumination*, and *explication.* Finally, as the final phase of this journey, *creative synthesis*, I will present my findings in the form of a walkabout. The walkabout will be followed by an analysis and description of the insights gained as a result of this process.

The purpose of this study was to describe a public high school as it might be seen from the perspective of new science explanations. In doing so I hoped to find greater personal understanding, and perhaps offer insights that might add to the conversations surrounding school reforms. This heuristic study relied on the intuitive or tacit knowledge (Polanyi, 1969) of the researcher and individuals who agreed to participate as co-researchers. Together we followed Moustakas' (1990) stages of *initial engagement, immersion, incubation, illumination, explication and creative synthesis*. My own *initial engagement* with this material came several years ago, when I first encountered it in Wheatley's 1992 study *Leadership and the New Sciences*. Since then I have *immersed* myself more deeply in the tenets of the new sciences. However, for the co-researchers who agreed to help in this quest, this was, in essence, their *initial engagement*. During this expedition certain individuals

accompanied me on different legs of the journey. Seven coworkers agreed to help me explore the school, sharing their experiences and insights. As a 24-year veteran teacher, I had classroom experience at the high school level in social studies and special education. However, I needed others to help me see the whole school. In selecting my co-researchers, I sought representation from diverse areas of the school. Because many of these people had held different positions in education throughout their careers, they brought experience beyond their current roles. This pool of experience included that of a secretary who has worked in many schools in different positions held positions as finance secretary and office manager. Another volunteer was a vocational counselor and former science and homemaking teacher. They were joined by a custodian, a librarian and former social studies teacher, an administrator who previously taught speech and drama, and a teacher with classroom experience in science. English and foreign language were taught by the last participant in this study. Experience in public education ranged from four years to over 30 years. Most had worked in secondary schools for at least 15 years.

Of the seven travelers who joined me in this quest, none had previous exposure to the new sciences. Due to of time limitations, the *immersion* process for the co-researchers consisted of reading selections from Briggs and Peat (1999), and an assignment to view the film, *Mindwalk*. After this *immersion* process, a period of *incubation* followed. The material was set aside for three to four weeks. Finally, the co-researchers were asked to *explicate* any *illuminations* they had in two general discussions groups and later, in individual interviews with me.

After each meeting or interview, I transcribed the taped conversations and then *immersed* myself in the information. These data were then set aside as I continued to *immerse* myself in new conversations and interviews. When all my co-journeyors had related their own stories and insights and it seemed I was generating no new data, I set all the material aside for a period of weeks and let it *incubate*. During this time it was amazing how new ideas began to seemingly pop out of nowhere. I recorded these *illuminations* as they came, simply writing them down with a brief explanation, to be considered at a later time. It seemed a purely random process, as these ideas might come into my consciousness when awakening, cooking, teaching, talking on the phone, or watching television. For me this became the process of *illumination*. After a period of time spent *incubating* and recording *illuminations*, I began the process of *explication*. I returned to the data and records of illumination, ascertaining themes that were emerging. During this process, the *illumination* process continued and could almost be conjured. If I had trouble tying information together I would *indwell* the information as described by Moustakas (1990). Indwelling requires an intense focus on the information for a period of time. For me the best time for this was usually right before I went to bed. This became the most predictable time for *illumination* to emerge. I was aware that I had informally done this many times in my life when something was bothering me. But it was not until this experience that I began to see that *illumination* followed predictably - as a *rule*, rather than as an *exception*. Indwelling focused my mind on the subject, and sleep allowed my tacit powers to concentrate on that problem without interference.

Though these people had limited knowledge of the new sciences per se, they shared their expertise and experiences in education and provided rich examples and descriptions that helped me to develop a multidimensional portrait of a public high school. Through formal interviews and informal discussions during the course of this investigation, their continued interest in the project buoyed my own enthusiasm. I remember several occasions when one or another of them found some new *illumination* related to the new sciences. They were as excited as I had been when I first began to see these new tenets seemingly popping out of the woodwork. Interestingly, none of these people had difficulty seeing educational implications for these tenets. For most, these ideas affirmed things they already intuitively felt or believed. In addition to sharing their own experiences, two of seven agreed to read the original composites I *explicated* and helped me refine them through additions or corrections.

This study was qualitative and subjective and reflected the unique perspective of the individuals who participated. Because of that, it would not be replicable elsewhere. It is generalizable only in that people in other schools might have had similar experiences. The findings of this chapter were structured around the concept of a walkabout. This walkabout served as the final phase of the heuristic research method, the *creative synthesis* of the data. After *explicating* the data, I began to create the a *composite portrait* of our experiences. In this walkabout, the *I* of the narrator reflects the experience of myself *and* these seven co-researchers. As in a walkabout there can be only one traveler, so only one voice can be heard. The voyager leaves familiar bearings and routines (in this case, the modernistic paradigm) and walks into

a space of images, memories, sounds and sensory stimuli, relying on intuition for direction. Shedding modernist preconceptions, the traveler is immersed in the quest. Guided by an inner, almost spiritual power, the walker focuses on the expedition.

Findings – The Walkabout

Having traveled a great distance, this journey cannot be measure in miles. I began this quest with the notion that I could *see* a public high school by removing the lens of the modern, mechanical, factory paradigm and replacing it with another lens, that of the new sciences. However, as I began to shed the lens of modernism, I saw the school laid bare, without the reductionistic hierarchies and compartments that distorted or hid what was clearly there all along. I was jolted by the notion that if I took off one pair of glasses and replaced them with another, I would simply have another contrived and artificial vision of the school. I did not want to cram what I discovered into a new box. I simply needed to see what was there, without glasses at all. In a sense, I felt like the travelers in the *Wizard of Oz*, when Toto pulled the curtain away to expose the wizard. I wanted to reveal the insidious smoke and mirrors of modernism, exposing the fog and noise machines that distracted us from seeing what lay outside the box.

Almost immediately I envisioned the geography transparencies I had used in my history classes when teaching about World War II. The first was a geographical footprint of the continent of Europe, showing things like land formations, bodies of water, population distribution. A second transparency overlaid the first. This one showed the pre-war political boundaries of the area. The third overlay showed the changes that occurred as a result of redrawing the post-war political boundaries. How

much did these artificial lines change the relationships and interconnections underneath? Fifty years later the world witnessed the reunification of Berlin and Germany, at the same time viewing the violent dissolution of the mishmash country of Yugoslavia. Had the lines drawn over the face of Europe really changed this land at all? Did the lines have meaning only to those who drew them? Did they exist only to allow the power brokers to believe they had control?

I wondered if public high schools suffered from the same process. Were they victims of artificial, externally imposed paradigms? Could I remove the *plastic transparencies* and see what lay beneath? Was that even possible? How could I do that without imposing a new set of values and beliefs? It was then I decided to work backwards. Instead of looking for examples of new science metaphors, I would have to peel off the layers of modernism and see what was left. Then I would try to find an explanation of what I found. I intended to be satisfied whether I found a new science explanation or not.

In order to leave behind the school I had seen through a mechanical, clock work paradigm I had to be vigilant. I had to remind myself often that the clocks were still ticking in my head. I have several old clocks in my home, some over a hundred years old. I wind them twice a week to keep them ticking. They chime or bong on the hour and half hour. I rarely notice. Before my granddaughter was two years old, she always noticed the clocks. By the age of two, she didn't notice them so much anymore. She was already learning to *not notice* details that existed in her world; becoming deaf and blind to them. In a sense, this journey would require me *to see* the details to which I had become deaf and blind. The superimposed transparencies

would also have to be discovered. I would have to see both, simultaneously. The difficult task would be to determine what existed and what only pretended to exist.

In many respects, this walkabout became a mindwalk; the milestones of the journey occurred in my mind. The walk has ended, for now, and I have recorded what I found. What follows is a token of that experience; a description of my discoveries.

The Organic School Metaphor

The mechanical view of the universe left its mark on the public high school. As I passed through the building I was aware of the hierarchy of laws, regulations and regulators that attempted to determine and control what happened within those walls. Beginning with officials of the national government, a flow chart could easily be created depicting the power structure that descends from the nation, to the state, to the city, to the district and finally into the school building. Those in the last boxes in this schematic, labeled teachers and then students, appeared to have no where to go, but up. I was reminded of a political cartoon I had seen from the French Revolution. A peasant, tattered and emaciated, is stooped over and carrying on his back a well-dressed and well-fed noble and clergyman. Meant to support the teachers and students the bureaucrats are now served.

Zooming in, I saw this school divided into departments with labels *like social studies, math, science, and English.* Each department was chaired by go-betweens who translated administrative directives, theoretically to serve the needs of classroom teachers. Each department followed a state-mandated curriculum and was (or soon would be) tested to determine whether this school was in fact doing what it was supposed to do: produce *capable* high school graduates, or at least

students who tested well. Each department had subdivided the part of the curriculum each teacher would *cover*. I could have spent days, weeks, months or even years making my way through the maze of hierarchies, departments, curriculum mandates, school laws, attendance and behavior codes, pay scales, career paths. I wondered how many people in education *never* saw a human child? I did not want to know. It was politically expedient to proclaim the school was child-centered. It was just difficult to find evidence that such was the case.

I found ample evidence that the factory model was alive and well, on the surface. However, I was interested in discovering what lay beneath the surface; under the hierarchies, the regulations, the departments, the mandated curriculum. Was there in fact a factory whose whistle started the conveyor belt of learning? Were teachers pouring carefully measured doses of knowledge into students who passively complied with teacher instructions and demands? Were these products jumping off the conveyor belt after three years, holding a diploma stamped *capable,* no worse for wear and tear and ready to make the world safe for democracy? Concealed by the overlay of *what should be* from a factory perspective, I found *what was*.

What was did not resemble the factory any more than a human being resembles a well made clock. Underneath the factory metaphor, I found human students, not products to be counted and tested. They were unique people. They had different names. They came from different places, had different family cultures, and did not all speak the same language. They were one-of-a-kind, living organisms. No two were exactly alike. They made their own decisions and believed different things. They were driven by reason, by emotion and by intuition. Sometimes they made

mistakes and often they did things well. They were predictable and unpredictable. They did not all have to use the restroom at the same time. Sometimes they were active rather than passive. They were ever growing and developing, evolving in many directions at once, yet never exactly like anyone else. They were complex; their traits infinite. They were much more than *all* of this.

In viewing *what was* beneath the boundaries of the mechanical metaphor I found teachers, secretaries, bus drivers, principals, counselors, cafeteria workers, librarians; each with jobs to do, each a living, breathing human being. These people knew students by name, by personality, by strength, by weakness, by family, by behavior trait. Many of these people knew, or will someday know, the futility of the factory metaphor. When these people confronted the factory model they said, "I wish it were that easy!" Some people will always hear the clockwork ticking in their heads. When they come face to face with the factory model they ask "What am I doing wrong?"

Whether they favored the factory model or thought it is obsolete, mechanical thinking was still the primary default metaphor for most adults in this school. It was the metaphor they thought from when confronted with problems. And why shouldn't they? This was the metaphor they grew up on. This metaphor saturated the school's educational tradition, educational legislation, educational structures, and educational reforms. It provided the language with which teachers thought. Even if you are aware of the clockwork ticking of the default metaphor, it was difficult to imagine a structure for education outside of it. It seemed pervasive.

This school had rules and regulations ample enough to blot out any organic need that might arise. It was run by the book (fat with policies and procedures), with schedules and bells, and armed policemen in the halls. It was regulated by the clock and every effort was made to adhere to the schedule. So how did this school exhibit an organic nature? It was difficult to find evidence of this in the policy and procedure manual. In fact, there are obvious attempts to squelch or regulate the organic nature of individuals. Even bodily functions like hunger and elimination were controlled. Eating occurred in a particular place at a particular time. Food and drinks were not permitted in the classrooms. Restroom breaks had to be taken between classes. Interest in the opposite sex could be expressed only in hand holding. Coats could not be worn in the classroom. Sleeping in class was considered inappropriate. Ill students were to stay home. All students were expected to arrive in class before the bell rang every period. The list went on.

Amazingly, though the clockwork ticked in their heads, it did not tick in the hearts of those compelled to work in this building. Time after time, as I wandered the halls of this school, and spoke to people, I found adults and students solving mechanical breakdowns *organically*. Upon observation, the organic nature of people themselves could find accommodation within these rules and regulations. As custodians could attest, on a typical day most classrooms offered up candy wrappers and drink containers; evidence of snacks surreptitiously consumed in spite of the rules. Nowhere was this more obvious than in the office itself, where student office-aides often brought chips, cookies, candy and other food products. It was not only the students who broke the rules, often the secretaries had bowls of candy on the their

desks for students. The foreign language classes had *culture days,* which marked the particular holidays of the culture being studied. Culture days always included the sharing of food. Holidays brought treats from teachers and students, as well as from the PTA. Many of the clubs and organizations in the school sold candy or cookies as part of their fund raising. These items were often consumed during classes. In spite of the regulations, when the aroma of rolls cooking in the cafeteria starts wafting through the halls, attention tended to shift from the subject at hand.

Likewise, though schedules were made for restroom breaks, when emergencies occurred students were accommodated. Told to stay home when ill, the state required student miss no more than 10 days per year. Many students came to school ill, and there were places for them to go if they did not feel well. Though sleeping in class was unacceptable, some teachers simply ignored sleeping students. Students slept because they are tired. They were tired because they did not get enough sleep. If they were that tired they probably were not going to be intent on learning anyway. Classes began at 8:00 A.M.; early for adolescents who could not seem to get to bed early. For some students, the weekends were not long enough to catch up on sleep.

Perhaps nowhere in the school was the organic nature of students more obvious than in the hormonal pull of a teenager's emotions. It was not unusual to find a mix of emotions being expressed on a daily basis throughout the school, by virtually any student. I did not wander far before witnessing the full spectrum of human emotions: from tears, anger, violence, and depression to jubilation, concern and love. Administrators and teachers, too, exhibited emotions that might influence their

behavior on certain days. Could these emotions be controlled or squelched by policy and procedure? Could they be predicted or organized? This school had two armed policemen that patrolled the halls. Was this evidence that emotions could be controlled or could not be controlled?

The weather offered another organic aspect to the school day. Experienced teachers believed that they could predict weather changes by the behavior or noise level of their students. I was not aware of a study that had measured this, but from my own experiences I would tend to agree. The influence of weather on behavior was subtle but noticeable. In this high school, spring fever was notorious for producing sleepy, unmotivated students, and probably a few teachers as well.

Finally, the factory manager might hope to produce standardized products filled with knowledge of the curriculum. Teachers, however, heeded the organic rhythm of their hearts over the mechanical ticking in their head. The factory goals appeared to be negotiable. Teachers had a hard time sacrificing students to the system. When they had to choose between doing what was good for the system or doing what was good for the student, the choices overwhelmingly favored the student. Second, third, and even fourth chances abounded; to err was human after all. No one knew or believed that more than the teachers I observed. Many teachers realized eventually that the subject matter they taught was a vehicle, not the journey and not the destination. They also understood that not all students left the station at the same time, or traveled at the same speed.

Systems Thinking, Interconnection, Relationship

According to Fleener (2002), modern science relentlessly reduced the physical properties of life into its simplest forms, often addressing the form and function of these elements in isolation. Analogous to the development of keener, more highly powered microscopes, the dominant, modern world-view has focused upon detail, sometimes creating the illusion of distinct parts, operating independently of the larger systems to which they belong. By searching out and studying the tiniest particles of nature in isolation, modern scientists have endeavored to construct an understanding of the whole. Because of this approach their understanding remains incomplete, even illusive.

What understanding would emerge if all the individual dots were removed and separately studied on the canvas of a pointillist painting? By removing single daubs of paint from the context of the whole, what would become of the *relationships* of color, light and form that allow us to view the completed scene? Modern science brilliantly cracked the code of human genetics, shattered the sound barrier, split and smashed atoms. It had broken, dissected, and dismembered nature to the quantum level. The effect, as we learned in nursery school, was that all the king's horses and all the king's men could not always put Humpty Dumpty together again. Something irreplaceable had been lost.

In school we learned to subdivide the body's senses. Eyes see, ears hear, tongues taste. By studying the senses in isolation, we assumed we had learned all there was to know about sight, hearing, or taste. However, as the best cooks knew, it was the relationship of the senses that determined our appetite and our response to the

things we ate. We tasted with our eyes long before we tasted with our mouths. Regardless of a pleasant taste, or mouth-watering aroma, the sight of blue food was unappealing. Salivation could be stimulated by cooking sounds (frying), aromas (bread cooking), or even emotion (depression). The sound of crunchy celery was inviting, but the sound of a crunchy steak was not. Music and emotion influenced the digestive process as much as the proteins, carbohydrates, and fats that we ingested. The act of eating, in fact, engaged the entire body. The isolated and defined sub-systems of the body, in reality were not separate. They acted together in relation to one another constantly, whether eating, sleeping, exercising, reading, watching television, or driving a car. People were more than a combination of separated biological sub-systems. The body was not separated from the mind. People were whole. Modern science reduced us to the *category of human being,* while separating and alienating us from the holistic *experience of being human.*

The *new sciences* have attempted to view phenomena in their complexity, not in their simplicity. Systems theory might help us to understand the nature of individual phenomena in *relation* to the context of the whole. This might force us to take a step back from the reductionistic close up, and view the bigger picture. Holistic vision would require us to embrace all data, to see it in its entirety and in its interconnection to everything else. No longer could data falling outside the bell curve be disregarded. *Everything would matter.* In this sense, phenomena could not be observed from one view point or another, but from multiple perspectives. We could look at individual trees, but we should notice the forest, as well. We could seek the needle in the haystack, or envision the haystack from the perspective of the needle.

Concentrating our gaze on the positive spaces of our vision, we could refocus to observe the negative spaces surrounding them. Like pushing a zoom button on a camera, we would adjust our depth of vision to see both the detail of the moment and the context within which the detail exists. We would come to rely on both conscious awareness and tacit intuitiveness. We would come to understand that nothing existed in isolation. Everything was related, interconnected and part of the system.

Often the significance of context might seem slight, as when a stone is lobbed into a pond. From the shore, the effect would be subtle, almost imperceptible, except for the telltale ripples on the surface. Zooming in, we might find evidence that the pond is changed forever. The stone had caused a minute rise in the water level. This in turn changed the shoreline. The ripples continued past the point that we could witness them with our own eyes. When terrorists flew planes into World Trade Center towers, the effects rippled far beyond the scope of our immediate perception or prediction. The effect on air travel and tourism was obvious; layoffs of employees, predictable. But who could have predicted the terrorist's acts could cause the U.S. Mint would lay off workers? Record donations to charities, put huge numbers of coins back into circulation. New coin production was slowed. Mint employees were no longer needed. Nothing occurred in isolation. When one thing changed, its effects rippled throughout the entire system. The changes in one system were echoed in other systems. Some effects were more easily seen than others, but systems theory demonstrates time and again that *everything matters.*

As I wandered this high school, I easily found the template of reductionism. Where else in life would history be divided from science, from mathematics, from

literature, from reading, from sports, from music - from the context of life itself? If a 17-year-old student wished to compare the velocity statistics of a baseball pitcher in 1920 with a pitcher on a team today, which class could accommodate this? Was it physics, biology, mathematics, history, sports? Was it even worth noting? The curriculum for this school was developed at the state level and was imposed from the top down. Accountability for successful curriculum instruction would be measured annually, through standardized testing that, theoretically, measured what students had learned. Testing reduced the richness of language to spelling, punctuation and grammar. Chemistry and algebra were reduced to equations and computation. The nation's history (without context to the past, present or future) was reduced to 50 names, dates, or places. By these standards, the concept of classrooms of people was reduced to rooms filled with automatons, soaking up facts to be extracted later.

The reductionistic bureaucracy separated learners into age groups disallowing what was known about their fluid, internal and unique development. This imposed structure assigned students to separated areas, away from families, communities, and nature. Could this generate within them a sense of their place in the universe? When a child had difficulty, the factory managers focused on what was broken, rather than what was complete. A child who lagged behind the rest in some regard, was cut off from the group and examined through microscopes, searching for defects at ever more minute levels. Specialists tested and measured, smaller and smaller pieces of these students. Other experts were assigned to focus on more specialized instruction for the purpose of fixing *The Problem.* The totality and humanity of the child was lost in the process. Emphasis shifted to the *problem,* negating the importance of the

person. Who was this child? How did the *problem* relate to the context of his life? Was he happy? Was he kind? Would he be a good father? What did he love? How long would he live? Did any of this matter? The child *became* the problem. The context of the child's life was ignored. Minute fractions of his being, with no past, and no future were examined. By addressing the minutia instead of the bigger picture, no one recognized that nothing could be changed in isolation. The student's world was turned upside down, and in effect it forever changed that student's big picture. It is with little consolation that it was done with the best intentions.

During my walks, I found teachers, often isolated to separated parts of the building, had different planning periods and separate lunch hours. They could easily lose their connection and relationship to the whole system. They could easily lose sight of the *whole* student, viewing him only in relation to themselves and their 55 minutes together. One saw Tim as a math student, while someone on the other side of the building saw Tim as their English student. Tim was also a science student, a football player, a troublemaker in the hall fourth hour, a teenaged father, and a gifted singer. What we each saw in isolation was really only the tip of the Tim iceberg. Like the blind men trying to describe the elephant, teachers often focused on trying to develop their own specialized vision of Tim. They made decisions for Tim, based upon a very limited picture of him. If Tim didn't do his homework last night, he was a slacker. He was going to stay after school today until his work was completed, no if's, and's, or but's. Later that week , it would be discovered that Tim was in an accident during the weekend. He spent Sunday night in the emergency room with his younger sister. He came to school, because he could not miss any more days. (The

state mandates no more than 10 absences.) He had been absent often since his parents split up. When his dad left town, Tim went to work to help his mom make ends meet. He got really tired and some days just stayed home to catch up on sleep. So how important was his homework assignment? Why did it take a tragedy for details of a student's life to emerge?

Tim represented a composite of students that have passed through this school over the years. The high school was filled with Tims, each a good deal more complex than the tiny parts seen in separated classes. Teachers were often surprised to find that a student who had done well for them all year was failing another class. Likewise, teachrs have been amazed to discover years later that among the students in their classes were painters and poets, murderers and thieves. The fraction of them that they knew was someone entirely different. Approached from a systems perspective, this is not surprising. If we understood that in systems *everything mattered,* better ways would be found to work together to better understand the whole people who walk into our classrooms. There was no person or agency responsible for the *whole* Tim. There were many splintered people or classes that were responsible for pieces of Tim. It was left to Tim to put himself back together again.

At this school, the schedule of the school day was not conducive to getting to know whole people. Typically, teachers had 130 students randomly divided up into five classes. That allowed a little over two minutes of individual interaction time, per student, per day. The schedule controlled the time available for learning, as if it could be programmed and controlled. Indeed, it was expected that the classroom teacher do just that. According to this state, after completing three, 180 days school years, spent

in six classes per day, the students at this high school would have soaked up enough isolated data to make the difference between success and failure in their future lives. The state placed no value on interconnection and relationship.

The truth of this school was that a reductionist template definitely overlay it, but it did not suffocate the dynamic system operating beneath the surface. There was no doubt that educators tried to appease the government's standards, the test makers, the reformers. The bells rang, the students filed in, instruction began. But as I sauntered through the halls it was immediately obvious that something was not quite right with this formula. Not all students made it to class, neither did all teachers begin instruction with the bell. The clockwork was in operation, but only superficially. Beneath the surface students and teachers were involved in ongoing relationships. Human needs took priority, the schedule was secondary. If a student was in need of the teacher's help, class did not start on time. Sometimes it did not start at all. Teachers intuitively knew that *everything mattered.*

Within the first few weeks of school, teachers and students began to know small things about one another, despite reductionist schedules. By mid-semester, the teacher and students had developed a fairly strong relationship. Teachers certainly did not know everything about all their students. There were always surprises, but teachers knew far more than might be predicted. They knew which students needed more encouragement, which students needed a firm hand, which students needed the freedom to explore beyond the curriculum. Often, they also knew which students were having trouble at home, which students worked after school, and which students were athletes. Teachers relied on interconnections with a student's other teachers,

siblings, friends, and parents. They courted anyone and anything that would aide them in establishing a more meaningful relationship with their students. As much as teachers knew about their students, never did I hear a teacher say they knew too much about their students. I suggest this might be the reason teachers lobby for smaller class sizes. It appeared to be much easier for teachers to get to know someone in a class of 25 students than in a class of 35 students. Teachers were constantly seeking out more information about the students they worked with. They intuitively knew this was important. They knew *everything mattered.*

Some teachers also understood that they could not reach all students. It was good that students had more than one teacher. It was good that teachers came in all types of packages. A wide variety of teachers were observed and remembered. Some of them seemed really strange. I wondered how they could possibly have influenced any of these students? Then one day, I would see them walking down the hall with a student who really even looked like them! These were teachers who had different styles, approaches, and philosophies. Naively, (or egotistically) I used to think that if they weren't like me, they weren't doing a very good job. It took me a long time to realize I was really good with only *some* students. I have failed miserably with others. I breathed a sigh of relief when I saw that students I could never reach developed a relationship with another teacher, a counselor, or an administrator. I knew they needed that. In a high school it took all of us. Attempts to create a formula for good teaching were doomed. The organic universe was built on variety. There was no one-size-fits-all teacher. No one could do it alone. Likewise, no parent could do it alone, and no student could do it alone. It took everyone. Each offered a unique

contribution to the relationships and interconnections within our system. The greater the diversity the greater the chance a child would be served. *All of us mattered.*

Over the years, teachers have established long lasting and significant relationships with students who were once in their classes. Often, in the larger community teachers are approached by a former students. The students explain how much the teacher influenced them. Often this is greeted by a feeling of guilt on the part of the teacher. They regret not being aware of the power they had to influence the student in better ways. Some students needed care and concern much more than they needed the math curriculum that was studied. Former students may tell teachers how much they loved the class and how much they learned. But, truthfully, the student could not rattle off the content that was covered. They loved the class, because they learned how to do things they hadn't done before. They learned things about themselves that they hadn't known before. But more importantly, they cared about the teacher and they knew the teacher cared about them and believed in them. As I proceeded on my journey it occurred to me that this was the reason people taught. It was the reason people *should* teach. Teachers intuitively knew that everything about an individual is important. The more you knew about students as whole people, the greater your chance of helping them. The relationships and interconnections continue long after the classes end. These experiences are not unusual. Almost any teacher has had a similar experience.

As I roamed the halls of this school, my head whispered questions rather than answers. If everything mattered, what did students learn in school that seemed incidental and unintended, but important to them? What did they learn that was not

mandated by the state and not tested by their district? What did they leave with that helped them in life? Did students learn democracy by studying the ancient Greeks or the documents written by the American founding fathers? Or did they learn it by sitting in classrooms with people of all genders, races, ethnicities? Was it to their advantage or a disadvantage if they did not like some of these people, but they learned to tolerate them? Did it help them or hurt them to be routinely exposed to people from other socio-economic groups? Did it strengthen or weaken their beliefs, when in chance encounters they compared their own traditions and values with those of others? Similarly, how did they learn religious tolerance? By studying the Reformation, and the Puritans, or by forming relationships with friends who had different beliefs? Perhaps more importantly in high schools today, could anything positive come from sitting side by side with students who used and even sold drugs, with people who were potentially violent, with people who represented all the things their parents disapproved of? Did simply the process of coming to school and forming relationships with other people add value to their lives?

Going to high school in America, is today what it has always been to some extent, an intense process of growth, and development. It was not surprising that high school reunions continued to draw people back 50 years or more after graduation. These graduates did not come back to celebrate the math and science they learned. They did not come back to conjugate verbs. They did not remember the names of all the classes they took, nor all the students in their classes. They certainly did not remember their homework scores. They might have remembered high school fondly, or they might remember it with loathing. But they remembered it. The high school

years were a complex, confusing time when a person began to develop a sense of who they were, what they believed, and what they were good at. It was a time when lifelong relationships were developed. Quite often high points were proceeded by low points. Gains were weighed against losses. People were saved and people were lost. It was the high point for some, the low point for others. Ultimately, it was the relationships and interconnections that remained important over time. Like high school today, *everything mattered.* As educators, it is *that* we should remember.

Open Systems, Closed Systems

While reading Briggs and Peat (1999) I was reminded that the laws of thermodynamics demonstrated that in closed systems everything eventually wore out or wound down. The reason was entropy. Entropy built up in a closed system sending it on a downhill slide toward equilibrium. Equilibrium was the point at which a system ceased to change. A machine that has been winding down finally stopped at equilibrium. It lacked the energy to do anything else. Closed systems attempted to avoid turbulence brought on by change because they had the tendency to seek equilibrium. On the other hand, open systems allowed for the dissipation of entropy. An open flow of energy and information helped an open system move through periods of turbulence. While helping it escape equilibrium, it also got rid of entropy that had built up. When systems closed their boundaries and did not allow for the dissipation of entropy, they began to disintegrate.

Entropy kept the system from moving toward change. Chen (1998) described people who become entrapped by their own unchanging behavior patterns. For example, consider the characteristics of people who fought change and growth. They

tended to become *more like themselves* as they grew older. For example, people who were somewhat stingy when younger might eventually become misers. They filled up with the *sameness* of their stingy behavior. New behavior was never allowed to enter, so in a sense the person became a more concentrated version of himself. Other differentiating behaviors eventually become extinct.

Phenomena within school systems could do the same. Change was as threatening to schools as it was to individuals. This school tended to avoid change. Change used up energy and wore the machinery down. Frightening because it lacked predictability, there was no guarantee that control would not be lost. The problem was, this reasoning comes from traditional science rationales. Schools were not closed, mechanical systems. As open systems, the energy used to avoid equilibrium actually invigorated the system. It was analogous to expending energy on exercise. Physical exercise actually would give us *more* energy, while getting rid of the *entropy* that bogs us down. Allowing ourselves to move *with* turbulence actually would require less energy than fighting it, and the payback would be stimulating creative transformation. By remaining open to change, school systems would evolve and would be energized rather than worn down.

As I journeyed through the school, I was reminded of an example of this process that occurred several years ago in the social studies department. The teachers designed and built a computer network with Internet connections for each classroom in the department. This innovation brought with it a new excitement for teaching among some of teachers. At the same time, others avoided having anything to do with it. Similarly, some teachers spent hours learning how to use their first computerized

grade book. It took years for many teachers to buy-in to this time-saver, because of the effort required to learn how to use them. It didn't seem worth the trouble. Those who initially expended the energy never went back to the old way of calculating grades because the computerized programs eventually became energy savers. It had been 14 years since the first grade programs entered the building, yet there were still teachers who never learned to use one, and probably never would.

Limit Cycles

Open systems could mimic closed systems when limit cycles are introduced (Briggs, et al., 1999). Limit cycles could be described as efforts to control a system, setting limits to the degrees of freedom available for a response to change. By narrowing the number of behaviors a system might exhibit, limit cycles reduced behavior to mechanical patterns. Creativity and innovation threatened limit cycles because they opened the potential for change.

My travels through the landscape of the public high school revealed that limit cycles prevented schools from efficiently dealing with change. Centralized control often prohibited creative growth and innovation within schools. The fear was that if teacher were free to try whatever they liked, *control* would be lost. A year after the social studies department at this school successfully developed their networking operation, the central office shut it down. The district planned to develop a district wide network instead. It took three years for the district to replace what had already been operational. Was the district network better than the one constructed locally? Probably. Did it

slow educational application of electronic media in the classroom? Without a doubt. During the three-year delay, all growth and much enthusiasm were extinguished. How many eager teachers have had their wings clipped in the name of *control, order, and standardization* by the district office? An argument that has often been bandied about by local, state and national leaders was that it was not fair for one school to have things the other schools in the district did not have. Unless it could be done everywhere, it could not be done. This rationalization failed to recognize the real problem with this antidote. It created a limit cycle.

National standards and curriculum alignment were based on the conception of education as a closed system. The goal of both programs was to *control* what happened in every classroom. If the same thing was being taught in each classroom, on the same day the assumption was that everything was equal. Theoretically, all students were exposed to virtually the same educational opportunities regardless of the location of their school. There have been heated arguments on both sides in regard these plans. The new sciences showed arguments on both sides to be moot. Schools were open systems. When applied to the dynamic, open systems of schools, national standards and curriculum alignment would become limit cycles. They would squelch the creativity required to meet the needs of the unique, unpredictable individuals who walk into the classrooms, and the unique, unpredictable, local events that influence them. Leadership through domination and control led to the limit cycles of defined and regulated programs. Leadership through shared vision led to the creative evolution of dynamic systems. The collusion that orders: You *would* do this, *this way,*

would be doomed to failure. The encumbrance of national standards and curriculum alignment *will simply never happen.* The reason is butterflies.

Non-Linearity And The Butterfly Effect

Linear systems were predictable according to Gleick (1988). They proceeded in an orderly fashion from point *A* to point *B*, and they were governed by two factors: If you did this then this will happen. Non-linear systems had more than two factors. They were dynamic and far too complex to be predicted, like the flow of a stream or weather. In a linear system the initial conditions of a situation were not too important. Small differences at the starting point would yield small differences at the finish. The differences would be proportional; small changes would have small effects while large changes would have larger effects. The accelerator on an automobile would be a good example of such a relationship. *Speed* was *proportional* to pressure placed on the accelerator producing a clearly defined cause and effect relationship. Linear systems fit easily within the confines of the modernistic, world-view. Linear systems could be taken apart, studied and reassembled. Many people were comfortable with linear systems because they could, theoretically, be *controlled.* They could be monitored. They could be stopped, fixed if something broke, and then they could be set in motion again.

Gleick (1988) said in contrast, that in non-linear systems, the system's sensitivity to initial conditions was vital. Referred to as the butterfly effect, tiny differences in the initial conditions of non-linear systems would lead to disproportionately disparate outcomes. In non-linear systems, disequilibrium was not regarded as something that needed to be stopped, corrected and controlled. Rather,

this chaos was viewed as the vehicle that transports the system to a new, evolved state. Changes in equilibrium were regarded as opportunities for growth and new development, rather than seen as *fires* to be put out. In fact, from a non-linear view stability was stagnating, leading ultimately to extinction.

In a non-linear system, prediction is not possible with any certainty. However, neither is prediction needed to control the system. If a system iss seen as naturally evolving, chaotic periods are the last crisis before the change is adapted. Consider, for example, human growth and development. We could not predict exactly when a child will learn to walk. Neither can we control it. There has been no expectation that these periods need to be conquered and controlled. They are more akin to the surrender involved when riding the crest of a wave until it crashes to shore, leaving the wave and shore in an altered, evolved state. In this metaphor, predictable qualities are apparent, like the direction the wave is rolling and its general destination. However, the final pattern the wave etches on the shore cannot be known beforehand.

Non-linear relationships sometimes demonstrat effects that fall completely out of all proportion to the cause. Another way Gleick (1988) illustrates the unpredictability inherent in non-linear systems is through an examination of the law of critical mass, more commonly known as *the straw that broke the camel's back.* It is impossible to predict the impact of any particular event in non-linear systems because there is no way of knowing what preceded it. One added straw to a camel's load might cause a dramatically different effect than the addition of each of the hundreds of preceding straws. Or it might not. This also explains why we are stunned when individuals *overreact* to a particular incident. Without knowing everything that this

person has previously encountered, we cannot accurately predict their reaction. Accordingly, subtle influences, like the seemingly inconsequential flapping of a butterfly's wings, could unleash potentially radical effects on weather conditions thousands of miles away. A non-linear system's initial conditions still determine where the system will end up, just as in linear systems. The problem is, there is no way to know all the factors involved in its initial condition. As with the straw and the camel, we would be blindly placing our straw, not knowing how many more have been placed there ahead of ours.

The school I journeyed through was a non-linear system. It was filled with non-linear students, non-linear teachers, and non-linear administrators. In fact the school throbbed with literally millions of variables that could not be counted, listed or even known. There was no way of determining the exact starting point of all those variables. The combination of these subtle and sometimes not so subtle influences made it impossible to predict what would happen in any given school, in any given class, on any given day. Yet, those who saw schools as factories, not only failed to understand the teaching/learning relationship - they failed to take into account the butterfly effect. There have been many reformers, set on a national curriculum, who believed it was possible for every teacher of American History in the nation to be teaching the same thing, on the same day, in the same way. By disregarding the non-linear nature of the schools and discounting the power of the butterfly effect, reformers changed nothing but the jargon. By considering the implications of sensitive dependence to initial conditions, they might begin to redefine power and control.

Teachers I observed formally and informally shared ideas on many aspects of instruction. However, what worked for one teacher often did not work in precisely the same way for other teachers. This was true even within the classes taught by the same teacher. A teacher's lesson plans had to be written with a large brush rather than a small one. One class responded one way to a lesson, another class responded differently. In some cases, a teacher's shared lesson resulted in disaster for their coworkers. In developing lesson strategies, one size did *not* fit all.

Classroom management was another keystone of the modernist teaching model at this school. I recalled a student teacher asking his supervising teacher for some ideas on how to improve his control in a particular class. I wondered if his mentor would leave him with the illusion that control of a class was possible, at least until he had tenure somewhere. It has been a long time since I have heard a veteran teacher brag about having real *control*, let alone *power* over a class. Would student teachers come back to school if they understood how *powerless* they were in *controlling* the classroom?

In reality, thousands of tiny, seemingly insignificant butterflies entered the classroom each hour, any of which had the power to annihilate the best laid plans of the teacher. Most teachers at this high school faced between 120 and 130 students per day. That alone was 120-130 individual butterflies waiting to flap their wings. Each individual in turn had been influenced each day by at least one parent or caretaker, who had also been influenced by at least one other person during the course of the day. So far this was at least 360 potentially influencing variables. Each had also been influenced by one another, and any number of teachers or students in earlier classes,

day. So far this was at least 360 potentially influencing variables. Each had also been influenced by one another, and any number of teachers or students in earlier classes, who were also influenced by at least one other person from home. These influences did not account for any of the thousands of other events effecting classroom; conditions over which the classroom teacher had absolutely no *control.*

During the course of my walkabout, I found examples of the effects of sensitive dependence on initial conditions almost everywhere I looked. Butterflies flapped through pages of schedules, lesson plans, and grade books. Incalculable influences entered the classroom each day: from weather conditions, media stories, odors from the cafeteria, and noises in the halls, to anticipated ball games, rumors, and flu bugs. Students arrived or departed, actively participated or apathetically laid their heads down on desks, passed tests or failed them; conditions over which classroom teachers had little control and even less ability to predict. This school was infested with butterflies!

In addition to the multitude of influences generated within the school itself, during the day teachers and students were influenced by televised news stories. On the anniversary of the Columbine tragedy one spring, news stories hinting that copy-cat crimes would occur throughout the country had our teachers and students on edge. A pep rally was scheduled for the last period of the day to honor spring sports athletes. By second period rumors were spreading that an incident had occurred at another city high school (these rumors were false) and that *someone* planned to do *something* at the pep rally. The nearer we came to the time of the pep rally the more agitated the students became. After lunch the office began to get record numbers of

calls from parents excusing their children from afternoon classes. By the time the pep rally started almost half of the student body had gone home and the tension in the gymnasium was palpable. The pep rally proceeded without incident, but the butterfly had ruled the day. Little learning could have taken place in this environment of fear and panic.

More influential than the limit cycles created by the district office, was the subtle power a teacher had to build or destroy a child's vision of himself. Several years ago I was teaching an honors level class whose purpose was to recruit top students into the field of education. These students were the cream of the crop academically. During the course of the year we studied many aspects of education, including a unit on special education. Having been a special education teacher, I really wanted the students to understand the *big picture*; what was it like to be classified and labeled as a special needs student. With the help of another teacher a mock testing situation was created. The students were administered what they believed to be standardized tests used to determine special education placement and I.Q. *This test was not real.* My coworker came to class to deliver the test results and describe terminology (bell curve, standard score, percentile). Each student's score was reported confidentially, in a sealed envelope. Unbeknownst to the students, each was given a score in the mildy retarded range.

At the beginning of this discussion, students were shown the range of the *class* scores. Plotted on a bogus bell curve, the range showed most of the students with IQs in the average and above average range, however one student's score fell into the mildly retarded range. My coworker explained the expectations of students who

scored in the various sections of the bell curve in terms of intelligence and school success. He indicated that if one of the students in class had legitimately scored in the mildly retarded range, (as one score showed) this student would have difficulty getting through high school. College level work would be impossible, and holding more than an entry-level job without vocational training would be troublesome.

The students were polite, but very reserved throughout. Follow-up questions centered around clarification on the lowest student's potential academic success. Normally very talkative, the class didn't appear to have much to say. After a few minutes, (that seemed to drag on for hours) my coworker and I confessed the hoax. The students turned to look at us wide-eyed. To our surprise they physically came out of their seats with relief. Whooping and groaning and chattering continued for several minutes. The physical reaction these students had to this news was amazing to witness. In discussions following our confession, every student admitted that they had been stunned, and at the same time fully accepted the validity of the result. A few had been on the verge of tears. We all learned a lesson on labeling. A mere number on a piece of paper could change one's life.

The astounding thing was the effect this one unofficial test had on students *who had ample evidence that they were academically gifted.* They wouldn't have been in this class had they not been! Without knowing all the variables of all the students we teach how can we possible predict the effect our actions will have on our students? How often are students tested today? How deeply are students affected by the results of these tests? Can we truly say testing has no negative effect on students?

Teachers intuitively know they have the power to influence students in limitless ways. Teachers might not be aware that power has a name. It is called sensitive dependence to initial conditions, the butterfly effect. Small influences can create huge differences. Briggs and Peat (1999) explain it like this: "Subtle influence is what each of us exerts, for good or ill, by the way we are.... Our attitude and being forms the climate others live in, the atmosphere they breathe. We help supply the nutrients for the soil where others grow" (p. 41).

I have lost count of the number of teachers who have told me of a student who returned to tell them that some little, insignificant thing they said or did made a tremendous difference in that student's life. These moments that change lives are not predictable, controllable, or even repeatable. But the are sublime. If they happen, it is the butterflies we must thank.

Bifurcation Points and Irreversibility

As Capra (1996) described it, during the early stages of change, a system was gradually pulled further away from equilibrium. First a system utilized previously successful behavior to return itself on a path toward equilibrium. When this failed, the system introduced new strategies to deal with the problem. These behaviors would either steer the system toward stability, or create greater change. A bifurcation point was the point at which the system followed one option rather than another. Each bifurcation, like the metaphorical fork in the road, determined another set of relationships, leading to further bifurcation in an ongoing, cascading sequence. At any given juncture, it was impossible to predict exactly what reaction the system would encounter. A bifurcation could draw a system into greater turbulence or cause it to

flow harmoniously *with* the turbulence. The concept of bifurcation points allowed for visualization of a specific point at which self-organization began to occur. It is from this critical point that future actions or perceptions decisively shift from one path to another. It, in some regards, was the *point of no return*. As Reilly (1999) suggests, "What would have been the outcome if the system had moved in another direction? This cannot be answered. Bifurcation point decisions leave unanswered forever the question, 'what if?'" (p. 437).

Related to bifurcation points is the concept of irreversibility. Those familiar with the movie *It's a Wonderful Life* have a good depiction of this tenet. In order to show George Bailey the importance of his own existence, the angel, Clarence, showed him the flip-side of what life would have been if George had never lived. The life of George Bailey began as a single bifurcation and the world was forever changed by that event. Capra (1996) suggested that once a course of action is taken, every other possibility is lost. The world without us could never be. Once something had changed, there could be no going back. The system could not revert to its pre-change state. Irreversibility meant that each of us had altered the universe, simply by our existence in it and we continued to shape it with every breath we took.

In human terms, bifurcation points could be as simple as making a conscious decision. To uncover and record all the bifurcation points experienced within a high school during a single hour could easily take a lifetime. Bifurcation points emanated from all who entered the building. These points of departure ranged from seemingly insignificant to momentous in their potential for altering the system. The simple decision made by a teacher to attend school or call a substitute created a bifurcation

point. The class dynamics would differ in some respect as a result of that action. If the teacher did not enter the classroom that day, the classroom experience would be altered. The significance of that decision could not be predicted in advance. Even the best-written substitute plans would not guarantee the class would respond as if the teacher were there. There were simply too many variables. The decision to place one or another substitute teacher in that class, another bifurcation point, added an additional element of change.

Almost any teacher could recall the experience of a *class from hell.* In that class, nothing seemed to work the way it had with every other class the teacher taught during the day. It was predictable only in its unpredictability. The amount of energy needed to *control* this class was exponentially greater than the total energy needed to control all of the teacher's other classes combined. Interestingly, when one or two particular students were not present, the class might have taken a much less taxing course. By their mere presence in that class, a particular student created a whole new set of circumstances. One common solution to this problem was to move one or two students from this class to another class during the day. This decision often resulted in a more productive situation for all involved, even for the students who were moved. It was not always the particular student per se who was the problem. Rather it was the interaction and relationship of the combination of students in that classroom. Likewise, the presence or absence of a particular student produced bifurcation points often as significant as the teacher's own presence.

As I made my way through the school I observed that a list of bifurcations racing through this high school on an average day was unending. However, when

combined with the implications of irreversibility, one might hesitate to accept the responsibility of teaching. According to Sullivan (1999) irreversibility meant that, "Once a change takes place, the system is never the same again. Only fragments of the past are retained into the future. The past as a whole is lost with every evolution. Furthermore, a change in a certain direction implies that a myriad of other directions are virtually cut off..." (p. 412). By opting for one path, a system could never stand at that point and opt for a different path again. Overwhelming repercussions resulted from a simple decision. It might make one fear decision making at all. Yet, in the face of turbulence, decisions had to be made very quickly. This responsibility could lead to overwhelming stress. As Chen (1998) suggests, bifurcation points are "intensified through periods of chaos and accompanied by overwhelming anxiety. If not tolerated, the anxiety accompanying it may lead clients to resist change, keeping them stuck. If adopted, it can lead to an individual's transformation. ... Unbroken stability, on the other hand, spells stagnation and even death" (p. 12).

I observed teachers who viewed high school from the lens of modernism. Teachers could be insecure with the chaos and complexity of a dynamic classroom often because they did not see the hidden order in chaos or the potential for creativity and learning. Sometimes they dealt with the responsibility and frustration by trying to *control* everything in their classes as much as possible. They used the same *tried and true* lesson plans year in and year out. They generally tried to restrict all conversation or movement in the classroom. They discouraged relationships among the students or with them. Their classes stagnated, as students answered questions in a book, chapter after chapter, day in and day out.

Oddly, this would be the type of classroom many reformers idealize when they seek methods of replacing teachers with machines, controlling classrooms with structure and routine, and testing students at the end of the course on memorizable facts. In effect, this was nothing more than warehousing students. It was comforting only because it provided a perception of control when actually none existed. In the meantime it was a decisive bifurcation, but one that led the system on a path to equilibrium and extinction. It irreversibly denied the students and the teacher of the opportunity to adapt and grow.

It would be predictable that a person returning to a place where he/she had previously worked found it similar in many ways, yet forever changed and not the place it was before. Teachers experienced this irreversibility every year. They closed the classroom door the last day of school and opened it the following school year. The room, the books, the desks, the materials were as they had been when school ended. Nothing else would be the same, however. How could teachers bear to teach the same course and keep it interesting year after year? The answer was that what appeared to be the same on the outside, was actually quite different beneath the surface. Once a class was over, it was over. It was never quite the same way again.

Understanding the personal implications of the power of bifurcation and irreversibility could lead to a wondrous self-discovery. To understand that the universe truly and forever changed the day you were born is life-affirming. Recognizing the significance and potential of a single individual life is both inspiring and comforting. It gives an almost spiritual significance and respect to all life in the universe. At a time when so many teenagers sought the meaning of their existence,

what a welcome understanding this would bring. It should be known by everyone. How different high school would be if all students believed they were important and their existence mattered. How different high school would be if all teachers believed the same.

During this journey I realized that bifurcation and irreversibility meant that everything we did was recorded, *everything mattered. We mattered.* We could never erase what had happened. Our interactions with kids were often causal and done on the run. We could regret things and ask forgiveness, but in very real terms what had been done, was done. We could only move on from there.

Self-Organization

According to Capra (1996), the essence of life was self-organization. For him a living system was considered to be self-organized if it was self-maintaining, self-renewing, and self-transcending. To put it more simply, living systems must be able to not only survive change, they must creatively transcend the stagnation and monotony of equilibrium. Since living systems coexist with one another in the universe, adapting to change was a process of *co*evolution. Living systems did not simply adapt *to* their environments, they adapted *with* them. Adaptation was important for survival, but creativity was important if the system was to transcend the pull of entropy. *Co*evolution implied that systems were not at the mercy of one another so much as they were in a relationship with one another. Capra described this process in terms of an ongoing dance or conversation. Individuals were living systems, the planet and universe they inhabited were living systems. All evolved

continuously in relation to one another. Life was more than survival, it was creative transcendence. So where did that leave schools?

Capra (1996) describes three characteristics of a self-organized system. The first characteristic was a freedom to create new structures and behaviors in order to alter the organization. Most public high schools in the United States were free to create new programs, or modify old ones as the need arose. In the course of my quest I have found this public high school to be restricted by externally imposed limit cycles. However, democracy provided for feedback systems. Positive and negative feedback loops allowed this system to survive. For example, birds were able to fly as a group without hitting one another as a result of remaining open to the constant flow of energy and information provided by feedback loops. Students navigate crowded hallways in this high school without the aid of traffic laws. For the most part, they do not collide with one another.

Likewise, this school received positive and negative feedback from both internal and external sources. Internally, teachers and students and administrators exchanged feedback constantly through questions, answers, grading, evaluation, body language, and even the occasional emotional outburst. A smiling face on a student paper indicated the teacher had received positive feedback from the student through learning, and positive feedback back to the student as to how that teacher felt about it. A smile from an administrator told a teacher they could relax a little. A former principal would put a notes in teacher's mailboxes that said "See me seventh hour." These notes became notorious. Teacher's hated to get *See-me* notes. They had no way of knowing whether this would be positive or negative, and they had to wait all day to

External feedback loops inundated the school. Because education is a hot political and media topic this school, like others, was bombarded with feedback from these sources. Feedback from the community was only a phone call away. Formal and informal parent conferences abounded. It seemed virtually everyone in the community had some opinion or some concern related to the local public high school. Twenty years ago, this high school led a district movement to air-condition the schools. The public had to pass a bond election to fund this change. The public provided positive feedback on this issue by voting to pass the bond issue. More recently, the district attempted to pass a bond election for increased technology. The public did not favor this change and chose not to fund it. These were powerful feedback loops. Mandated state and national testing, approved through legislation was paid by tax dollars. Though seen as a popular reform and growing in size and scope for many years, the testing issue seems to be facing a developing resistance among parents and taxpayers who no longer support it. In effect, the limit cycles imposed on schools have been less than permanent features. These feedback loops have prevented the public schools from buckling under overzealous, momentarily fashionable or purely political reforms.

Capra's (1996) second criterion of self-organized systems was that they changed as a result of being pushed far from equilibrium. My walkabout allowed me to understand that this high school made changes itself when something no longer worked. That is, when it was pushed far from equilibrium. For example, every year someone would ask that some element of the student code be re-examined. Every year something that no longer worked was changed. However, very few teachers

believed the new change would last forever. Within a year or two, students found loopholes, and what was once effective became useless. For example, students found that according to policy, a student might have one hour of detention for cutting class, but one day of detention for their third tardy. Students tardy a third time simply did not go to class at all, receiving the lesser punishment. Sometimes policies were simply no longer enforceable. It was once considered outrageous for students to have neon blue, lime green, or magenta hair color, not to mention body piercing and tattoos. The organizer of a recent blood drive among seniors at this high school found donors in short supply. It turned out that fewer students were donating because people with body piercing or tattoos done within a year's time were ineligible to donate blood. Record numbers of students were simply ineligible to donate. Once such an oddity, it has become too prevalent to prevent. Suspending students with tattoos might empty the high school.

Today, it is sometimes difficult to envision what might be considered outrageous. In the case of student code infractions, the number of students exhibiting a behavior, combined with the number of parents who will no longer support the policy culminated in an inability to enforce a policy. Dissent reached the point of critical mass. When this happened, policy was changed. This high schools tended to be more reactive that proactive. Instances that appeared proactive generally resulted from societal turbulence that imposed itself on this school, even when no local difficulty existed. For example, school security was increased throughout the nation relative to the violence in society or in other schools, rather than to the actual violence in particular schools. Violence in this school was actually decreasing when the

decision was made to increase security. Ample evidence from this school demonstrated that change occurred when the system was pushed far from equilibrium.

Capra's (1996) third criterion for self-organized systems was that the entire system was interconnected non-linearly. Many connections within the school were linear. For instance, hierarchies of personnel assignments were made on a linear basis. Students and teachers were formally assigned to classes. Everyone had a job description, outlining the tasks for which they were responsible. Yet a web of relationships existed beyond the structured one, that was purely self-organized, formed on the basis of variables too numerous to count. Employees did many things not in their job descriptions and for many, these were the duties that brought the most joy and job satisfaction. Birthdays were celebrated, funerals were attended, wedding showers were given, food was cooked and delivered to the homes of those facing hardships by people not officially directed to do so. Employees filled in for one another in emergencies, and pitched in when a big project needing volunteers was underway. When a person was having a bad day, someone else noticed and with a note, a smile or a hug acknowledged and sympathized. The list went on. None of these were mandated duties. None of these were mandated relationships. None of this was officially planned and organized. These interconnections were purely spontaneous and self-organized. In many ways, these were the relationships that nurtured people during turbulent times, while maintaining the survival and transcendence of the system.

These kinds of relationships existed within classrooms between teachers and students and among students within the larger student body. There was a profusion of linearly organized student groups from choirs to football teams, from art clubs to drill teams. However, there were far greater numbers of non-linear, self-organized students groups: the geeks, the nerds, the preps, the cowboys, the skaters, the head-bangers, the goths. Every few years the names changed, but the groups continued to evolve. In spite of the smaller and smaller sub-categories, all stood when the school fight song was played, and most will cry and hug at graduation. They were interconnected in a thousand tiny ways to one another and to others within the community.

At the quantum level physicists found that subatomic particles are not found to exist as solid objects. Rather they had the *potential* to exist. (Capra, 1996) They seemed to exist only in relationship to something else. Students walking into a school were potentialities of relationships that would be formed with people within the school and with one another. How this potentiality played itself out was determined by each individual or thing encountered by the student. The potentiality of the relationship in learning was determined by the ability of the student, teacher, and material to form a relationship. Without teachers there were no students. Without students there were no teachers. One existed only in relation to the other. Either might be a learner. One might learn many things without a teacher. One discovers the ability to learn from the experience one has had in the world. Contrary to the traditional paradigm of power or control, the new sciences demonstrate a learning relationship limited only by the potentialities involved.

Strange Attractors

Systems are seen as complex by virtue of the number of variables that influence them according to Gleick (1988). The greater the number of influences the more complex the system. Likewise, the greater the number of influencing variables, the greater the opportunity for chaos. Any perturbation in any of the many variables could rock the entire system. Cutright (1999) pointed out that in the past it has been difficult to map quantifiable data in the social sciences because of the complexity of dealing with multiple variables. Social scientists have had to describe *patterns* of behavior qualitatively, rather than plot individual points. In the light of the new sciences, our vision could move beyond the two dimensional, linear cause-and-effect models.

Many people continue to see schools as simple linear equations; teachers teach and students learn. This has been measured and graphed in two dimensions, using the ideal model for modernist educators, the bell curve. Unrealistically, parents and legislators raised standards and added requirements, while insisting all students move to the above average portion of the curve. But they still envisioned the curve. They still saw the school in two dimensions. Until reformers begin to visualize the school in its complexity, and its multiple dimensions, we will continue to waste a great deal of time and money chasing an impossibility. The concept of *phase space* as described by Gleick (1988) afforded us an abstract way of visualizing a system. Phase space had dimension in relation to the number of variables involved. By visualizing complex relationships in phase space rather than on bell curves we began

to see the interconnected *patterns* that hold systems and, ultimately, the universe together.

Strange attractors can be seen graphically. Almost magnetically, they attract behaviors into a definable pattern. However, strange attractor patterns are complex. As Gleick (1988) describes them, no two points fall in exactly the same place and no paths cross. Each point within the pattern is completely unique and not replicated. The points in a pattern are infinite, yet the pattern is bounded within a finite space. Mathematically they are described as fractal; falling between dimensions, and infinite in their composition.

Capra (1996) points out that rather than predictability, these patterns reflect *tendencies* to follow a pattern. It cannot be predicted when or where the next behavior will exist, it is simply known that a behavior will have a tendency to show up somewhere within the limits of the pattern. As described in the film *Mindwalk* it could be that these individual points are simply potentialities, and exist only when we are aware of them.

Often during my mind walk I encountered students who displayed certain qualities that no one could explain. I would hear, "I don't know where he is coming from" or "Something is wrong with him" or "What's his problem?" When a student committed suicide, or committed murder everyone was stunned. No one could explain what went wrong. Later, however, as bits and pieces of information filtered in, a pattern began to emerge. The behavior's potentiality to exist now seemed apparent, though no one anticipated it earlier.

Darwin, according to Briggs and Peat (1999), returned from his world voyages with all the data he collected, carefully recorded in journals. He had information, but he had not yet discovered what it meant. Darwin sat in the midst of his many journals, wondering how he would ever find the patterns and interconnections needed to make sense of his data. At some point he drew a tree. This figure intrigued him for some reason. He continued to return to it time and again. As he focused on the diagram he felt compelled to label it *The Tree of Knowledge.* Amazingly, once labeled, this diagram began to *attract* data from his journals. Relationships and interconnections began to emerge until, at last, he could envision and describe the patterns of evolutionary biology. He had needed no new information. The information he needed had been there all along. His illustration of the tree of life had become a *strange attractor,* forming a shift in perception around which a new pattern of meaning developed. The data hadn't changed but his perception of it had. Nothing had changed, yet everything had changed.

Just as strange attractors influenced individuals, they also influenced groups of people in the school I saw. They could not always be named or identified, but I witnessed parts of the behavior pattern that evolved. What were the strange attractors that drew people when chaos occurred? During periods of turbulence, individuals confronted bifurcation points quickly. But what determined the decisions they made? Was it past experience, values, character, or novelty? What were the strange attractors that confronted those in the school and what determined the decision to follow one and not another?

One example that came to mind was the behavior exhibited by students in an assembly. Monitoring high school assemblies was like tending a campfire in a windstorm. It might work out just fine, but in this high school teachers generally patrolled the aisle in anticipation of chaos during the whole program. Everything might be proceeding nicely, until all of a sudden a student sneezed. Giggles erupted. From across the auditorium another sneeze was followed by more giggles. At any point the behavior could diminish or increase. Similarly, cafeteria food fights were generally not planned and choreographed. Rather, some point of attraction developed and people began to join in. Behavior could be triggered by strange attractors in classrooms, during fire drills, at sporting events, in teacher's meetings, or during graduation ceremonies. Sometimes, the *illusion of control* became a strange attractor. If students sensed someone in authority controlled their behavior then, in a sense, they did. This was really the basis for the student code of behavior. Perhaps they were attracted to the seeming predictability and consistency of the teacher, or maybe it was the relationship of mutual trust and responsibility developed with a teacher. For the most part, student behavior followed the path of least resistance, at least in high school. Most students did not swim against the current. It took less energy to go with the flow.

Fractals and Holograms

A phase space of almost unlimited dimension could be better envisioned by imagining its properties as being similar to a holographic image. According to Briggs and Peat (1999) systems, like holograms, had depth and dimension. They did not occupy much space. A system, like the school I traveled, existed outside the bounds

of the building, just as it did within it. The building could not contain the system nor could it wholly define it. Similarly, the factory model could not define the system because learning did not happen in a factory or a classroom, it happened *in a person.* Sometimes learning happened because of a teacher; sometimes it happened in spite of a teacher. Sometimes learning was experienced by more than one person at the same time. Sometimes learning happened in the presence of books and materials, some times it could be triggered by a single thought.

Fractals as seen to possess a property known as self–similarity across scale. According to Gleick (1988) this meant there was a basic symmetry within the fractal when seen from any scale or distance; the same pattern existed within a pattern whether viewed by microscope or telescope. The system was self-similar throughout. During this mindwalk I came to understand that to become a child again I did not have to run backward through time and space on a linear continuum. Instead, I simply allowed something buried within me to emerge. I was 50 years old, and 5 years old and 15 years old at the same time. I was aware of my age only in relationship to a mirror. Everything I was, or ever have been, could be pulled up from another dimension within myself. It was deeper not further away. There were qualities or essences of *me* that existed throughout the hologram of *me*. When I met people who had not seen me for 30 years, they knew *me* even through the wrinkles and gray hair. The *me* they knew was still there, easily recognizable. I was the same *me* I had always been. The essence of *me* was there regardless of scale or time or space. I had been *me* my whole life. In spite of the experiences that I imagined changed *me*, my essential

*me*ness had never changed. Growth simply meant that *everything changes, and nothing changes.*

On this quest, I returned to the high school I graduated from 30 years ago. It was still recognizable. Relationships had not changed, they just connected different people. The same dramas were being played out in classrooms in spite of the addition of advanced technology, telephones, and air conditioning. The system called high school was a hologram. It had depth and dimension. The old science hid the holographic qualities but the essence of the school lived at all scales and dimension. The living hologram simultaneously included all that had happened, all that was happening, and all that would happen. The *school* maintained its essence even as it changed. When I had left the school, something changed and nothing changed; everything would eventually change and yet nothing truly would change. A part of the school's essence was taken away when someone left. The part taken became interconnected with the individuals own system, a strand woven into the web of their lives. They might return to the school often, without ever going there physically. Its essence lay within them, buried in the depths of who they were. The particular essence of school they took with them was as individual and unique as they were. It had stopped in time and space but continued to live in a parallel universe within them. They remained within the school and the school remained in them.

Being Human, Being Fractal and Learning

Learning itself required relationship. When one learned it was through the collection of all types of sensory data absorbed into the being simultaneously from all the senses including tacit ways of knowing. Being human meant absorbing data,

ingesting it totally and in every possible way. We were not *dis*connected from our environments: we were immersed in them. Imagine a baby immersed in fluid within the womb. The fluid did not stop at the skin. It filled the pores. It was not obvious where skin began and fluid ended. The baby breathed the fluid which nourished every cell in its body. The baby was a part of the fluid, just as the fluid was a part of the baby. At birth the baby left the liquid environment that immersed it. Now the environment was air. Likewise, air filled the pores and the lungs and circulated through the child until every cell was oxygenated. The child was immersed in this new environment; not living *on* the biosphere but living *within* the biosphere. Because our eyes did not *see* these connections, we have had difficulty visualizing them, but the universe seeped into us constantly as easily as the air did. We were immersed in the universe; invisibly connected and indivisibly one with it. The heart of the universe beat within us, in rhythm with our own.

In some fashion, we self-organized with that which surrounds us. When new information formed a connection with prior experience we were sometimes aware of the connection being made. Perhaps while watching television a person suddenly also noticed an odor like that of something burning. This was a case of a relationship forming immediately with something in our awareness (a danger signal). We might also absorb information without being consciously aware of it. Walk into a room where the people have been arguing and the tension can be felt. It moved inside of you even before you noticed. Many people have had the experience of meeting someone for the first time and coming away from that meeting with a sense of uneasiness or danger. Often these first impressions were later confirmed. What had

we tapped into? How did we know these things? I remember walking past a cosmetic counter one Christmas, and suddenly feeling the overwhelming presence of my grandmother who had passed away many years before. Scent evoked memories flooded into my consciousness. New information (scent) self-organized with stored information (experiences with my grandmother).

After a period of time, data could seem to fade from existence. This was *how time heals all wounds.* The wounds never went away but they slowly moved deeper into our consciousness until we could go through an hour, a day, a week, without the constant gnawing emotions. During my journey through the school, I recalled that when my history students were assigned to interview people who had lived through particular periods of history they were always touched and amazed that something that happened over 50 years ago could still evoke tears and fresh remorse in the story tellers. Sometimes we experienced things that did not seem *to take*; we could not make sense of them. It might be that upon the next exposure, new relationships formed with those previously stored. This might happen again and again until finally there was a fuller pattern of meaning. Knowledge could not be *constructed* like a brick wall. Rather, it was *interconnected* like a spider's web.

When I started this doctoral program I encountered a number of terms and concepts that were totally foreign to me. Later, I could recognize the terms when I heard them again, but I still had no clear idea of what these terms meant, even after I looked them up and read through definitions numerous times. Eventually, I learned them, though I remained a bit unsteady with them. Some of the learning occurred because I was forced to find connections between these words and concepts in

application to something I was researching or writing about. It took a long time and many exposures before I felt somewhat confident with the terms or concepts, but I don't think they ever disappeared from my memory. I had to make connections to knit relationships among seemingly fractured and disjointed points of information. These concepts were always easier to grasp when holistically contextualized.

This is evident when watching a toddler learn to speak. The child rarely learned the words in a sentence in isolation. There was always a context. It was also more likely that they would learn complex phrases. They did not seem to focus on pronouncing or even recognizing the individual words, but they were careful to capture the intonation, facial expressions and gestures that helped them contextualize the phrase. In fact, they might have used these complex actions before their language was clear at all. I noticed that my students who have had reading problems often had difficulty spelling words because they did not realize they were pronouncing more than one word. Or they would spell words the way they mispronounced them. Due to their reading problems, they knew these words only from the context of oral language. In cases where students learned to speak nonstandard English, this difficulty was profoundly amplified. They could not identify the individual words within the phrases they spoke.

My mindwalk jarred a personal memory of my own difficulties trying to learn new phrases prior to visiting Japan. Though I had previous experience learning European languages, I was in no way prepared to learn Japanese. I listened to tapes, practiced the phrases and visualized myself using them. I simply could not remember them from one day to the next. By the time I got to Japan I knew less than five

words, and was unsure of the meaning of those. Within two days of actually interacting with people in a meaningful context, I learned phrases quickly. Like a toddler, I was repeating complete phrases with complex intonation and gestures. Often I had no idea of the individual words. However, it seemed almost effortless compared to my struggles at home.

As educators we had exposure to the information we needed of the learning process. We sat surrounded by our journals like Darwin, wondering what it all meant. What was *knowing*? How did we describe the point at which an individual *knows*? How did the learner *come* to know? How could the new sciences provide a way to see learning? Was there a scope and sequence of learning, or did knowing come from the relationships and connections experienced by the knower? Knowing was as individual as DNA. No two people knew the same thing in exactly the same way. The word *dog* did not evoke the same image in any two individuals because dogs were understood differently by each knower. This might be problematic in a classroom of 30 students attempting to understand the causes and implications of World War II. It was miraculous that students did come to know these things, but we had to always be aware that the knowing was as individual as they were.

Knowing and memorizing were not the same thing. A student might memorize hundreds of facts about World War II and have no real understanding of it. To be truly known, it must have been a part of a relational and interconnected pattern. To know that D-Day occurred on June 7, 1944 was meaningless in isolation. Only when immersed in the context and relationship of events proceeding and subsequent to it, did we begin to see the significance of this information as a turning point in a brutal,

human drama. We could not measure *knowing* if stripped of the context which gave it meaning. By measuring the recall of isolated facts, we were measuring meaningless raw material. Knowing was not a completed process until raw data had been connected within a meaningful pattern of relationship.

As a classroom teacher, I had often grown frustrated when trying to explain certain concepts to a particular student who simply looked at me with blank expression in spite of a my explanations. After a few minutes, students who understood the concept began to groan with impatience as this last holdout seemingly refused to understand. As I questioned the student, I found that many aspects of the concept *were* understood. In fact, it was not unusual for the student to repeat my explanations and examples clearly back to me. At a point of complete despair for both of us, after stretching for the last conceivable example, the student's eyes suddenly focused brightly. You could witness a light switching on. Then they exclaimed excitedly, "Oh, I get it!" and proceeded to rattle off their own associations and meanings, often seeing immediately the critical implications of this concept. Within seconds they emerged from *not knowing* to *highly complex knowing*.

Such episodes often left me both elated and flabbergasted and almost physically exhausted. It almost seemed as if I had *willed* this student to know. The best metaphor I had for knowledge transfer before the new sciences were scenes from 1950's science fiction movies where bolts of electricity jumped from my head and into the student's. I was always left wondering what key ingredient allowed this student to virtually *burst* into knowing. Later, the Star Trek series gave me a better visual metaphor to explain this phenomenon. For lack of a better name, I called it the

"Beam me up, Scotty" metaphor. When an organism was beamed aboard the Star Ship Enterprise, various random dots began to emerge from another dimension. At first, it was impossible to name the object being beamed aboard. However, before long a defined pattern began to emerge, finally allowing it to be named and described.

For now, this is also how I have come to visualize the pattern of the strange attractor in the act of learning and the state of knowing. People absorbed data constantly through sensory input. Because of the enormity of raw experience a person absorbed constantly, most of this was not explicitly (or consciously) known. The individual was often not even aware of this process taking place. For example, it was possible to retrieve information under hypnosis that was not consciously remembered, as when a person recalled the license plate number of a vehicle. Organically, all experiences were remembered tacitly (Polanyi, 1969). This knowing becomes explicit, or conscious, only when connections and relationships require it to surface. In a sense, tacit knowing was like a shadow knowing system. It followed us through our days, yet we were seldom aware of it. A shift in awareness might bring it into focus or *beam it up.* Or it might not.

Tacit knowing as described by Polanyi (1969) allowed us to know things we cannot yet explain. For example, when we *sensed* danger we were not always cognitively aware of the source. What we called intuition, was actually the reality we knew tacitly, rather than explicitly. By shifting focus, we might be able to determine the cause of our intuitive knowing. However, there remained situations that simply could not be explained explicitly. I was reminded of these during my walkabout. Many times in my own teaching I had the experience of feeling something was not

working but I could not put my finger on the cause. I intuitively knew something long before I could explain it. In some cases, I still can not explain the cause. At this point I believe that, in all inquiries I have, like Darwin, all the data I need to find the answer. It is within me. I simply have to evoke the strange attractor that will call the pattern into focus.

With this I have ended my walkabout through the public high school. By leaving familiar surroundings embedded in the modernistic paradigm I have walked into a space of images, memories, sounds and sensory stimuli, relying on intuition for direction. I became immersed in the quest. Guided by an inner, almost spiritual power, I focused on the expedition and found the answers I sought. What follows is the essence of what I have learned. I leave this for others, to mark the quest.

Analysis of Findings

Embarking upon this quest, I hoped to discover whether or not the high school could be viewed from the perspective of chaos and complexity. The evidence I found suggested that this high school is a self-organized system with multiple feedback loops. It showed evidence of non-linearity and profuse examples of sensitive dependence on initial conditions. I found characteristics of a living, organic system, filled with interconnection and relationship. Examples of open and closed systems, limit cycles, and systems thinking abound. Bifurcation points and irreversibility, as well as strange attractors, fractals, and holograms could be identified. Because of this, it is my contention that the new sciences offer appropriate metaphors for use in educational research and the interpretation of the intricate relationships within this school.

During the period I spent with this research, I was surprised to see recurring themes emanate. When I followed a particular metaphor to the end, it often returned to the same conclusion of the previous tenet. Several key themes kept emerging, but *holism* is the all-encompassing theme that seemed to tie the others together. The holistic nature of these findings made it difficult to separate or isolate these themes from one another. Studying the isolated parts of the school diminish the ability to understand the whole system. The parts of the school lose important meaning when removed from the context in which they exist.

Everything is Related and Interconnected

One theme that permeated the study was that *everything is related and interconnected.* Where one thing ends and another begins in a high school, cannot be known. Without context, it is not possible to fully describe a teacher or teaching, a student or learning. Each subject of focus is immersed within complex webs of interconnection and relationship. Cutting away the strands of relationship, is like stripping the life giving capillaries, muscle tissue, and nerves away from the bone, destroying the context in which it has vitality and purpose. The complexity of each part increases exponentially when seen in relation to the whole. Consider the relationships and interconnections of an individual student. Without seeing the student in the context of his family background, culture, belief system, economic class, personal goals and desires, or past educational experience it is not possible to fully know or understand that person. These are but a few of the infinite number of interconnections that influence a person. When we place 30 such complex individuals within a classroom, we exponentially increase the number of interconnections and

relationships. Before us, in any instant, we glimpse a mere *slice* of the complex whole that *is that individual.* One person exists for us at that moment only in relation to *how we see him* through our own set of complex interconnections. Like matter at a quantum level, we have the *potential* to exist in that unique way, *only at that particular moment and in that particular relationship* to one another.

Everything Matters

Because nothing happens in isolation, everything is related and interconnected and everything feeds back into the system. This means that every person, every action, and every thought has consequence. Whether an influence can be directly observed or not, once it enters the system it is considered at some level. *Everything matters.* This concept continued to emerge with each tenet I examined. Irreversibility suggests that nothing we do can be undone. Sensitive dependence on initial conditions suggests that we cannot predict the effect of the smallest influence. Non-linear, organic systems like schools must understand the power of each decision made. A simple smile from a teacher might completely change the path a child takes that day. The path a child takes one day, forever changes the journey of his life and the lives of those he influences. Every word a teacher speaks to a child has the power to sway a child and the complex web of relationship and interconnection in which the child exists. We simply cannot know how far our influence will be felt. The good we do can be boundless. The damage we do can be infinite, as well. Regardless of the effect, *everything matters.*

Everything Changes and Nothing Changes

Change is inevitable in any living, non-linear system. Schools are no exception. We choose to fight change or to move with it, but ultimately, *everything changes.* Throughout this study I found constant change. Sometimes, the change seemed inconsequential. Sometimes the change seemed monumental. However, at the same time I observed continual change, it appeared *nothing changed.* It was only after I returned to Capra (1996), that I began to understand this paradox. Capra explained that traditional science and philosophy seek *substance* while the new sciences seek *form. Substance* is found in structure (What is it made of? How do we weigh and measure it? How do we quantify it?). *Form*, on the other hand, is found in pattern (How do we map its relationships? How do we qualify it?). The theme e*verything changes and nothing changes* is a synthesis these two approaches. Together they give us a comprehensive understanding of the school.

When *everything changes* often it is only the pattern of relationship or perception that has changed. The school's patterns shift and change constantly, as do the relationships and perceptions of individuals within the school. As profound as these changes may be (as with paradigm shifts for example) the structures often remain the same or at least remain recognizable. For them it seems *nothing changes.* I was able to walk through the high school from which I graduated and feel as though *nothing had changed,* because the same structures were still in evidence; the building, the classrooms, the hierarchy, the grading system, the school buses, and the parking lot virtually identical 30 years later. Students were in classes and teachers were instructing. It appeared *nothing had changed,* and in the structure of this school

nothing *had* changed. Yet I felt alienated and estranged. Like a stranger, I had no pattern of relationship or interconnection with the people who now walked these halls. *Everything had changed.* Understanding the theme *everything changes and nothing changes* helped me realize why the educational reforms of the past two decades had changed schools so little.

Linear Reforms in a Non-Linear Systems

For the past 20 years educational reformers have been attempting to put square pegs into round holes. Reforms have often been ineffective because the high school is not recognized or understood as a non-linear system. Seen simplistically, from the perspective of traditional science and the linear, factory model metaphor, these reforms ignore the patterns of complexity and unpredictability of the real classroom. It is the *pattern* of butterflies not the *structure* of monkey wrenches that foil linear reform in schools. In the factory mindset, the business of education is to produce capable, competent and compliant products. The factory is a *structure* and the events occurring inside the factory are *controlled through structure.* Education is regarded as a *structured,* linear, cause-effect relationship. It is seen as something others do *to* you. However, children are not passive, dimension-less receptacles into which legislated curriculum can be poured. The more we focus on *structural,* linear reforms, the greater damage we do to our children, our schools, and our nation.

I found three types of *structural* educational reforms implemented using this linear, factory model. First there are curriculum changes (altering the formula poured into the passive receptacles). This reform can be seen in any number of failed attempts to alter curriculum in our district in the past 20 years: back to basics

movements, character education, phonics versus whole language, multicultural, education, and ever changing and increasing requirements for graduation. In this high school each graduating class for the next four consecutive years *have different courses required for graduation.* Does this mean students graduating one year will have to make do without the ultimate knowledge of the students who graduated a year ahead or behind them?

Reformers quickly and inexpensively institute this type of change: no teachers to extensively retrain, no new facilities to build, relatively little material or equipment to purchase. State legislators, teacher unions, and powerful political action committees can point to these quickly enacted reforms and claim to have made a difference in the education of our children. The problem is, these reforms can (and are) just as quickly and easily replaced. In our school, they generally seem to go away within three years - sometimes sooner. The current graduation requirements, for example, indicate reforms legislated several years in advance have become obsolete before they are ever instituted!

Another type of reform focuses on the *way* in which the curriculum is delivered to the passive receptacles. Focused on teachers, it emphases that there are appropriate and inappropriate *structured* methods (or formulas) for delivering the curriculum. In the past two decades, the teachers in this school have been trained in a variety of methodologies including: mastery learning, outcome based education, cooperative learning, assertive discipline, TESA (teacher expectations and student achievement), and learning styles to name a few. Implying that the problem with schools is the teachers' expertise, creating the right structure for workers to follow

will improve production. Supporters of merit pay belong in this group, also. Although they have difficulty agreeing on what constitutes merit, or how it should be measured, they do believe the failure of education is based on poor teaching. Interestingly they think anyone can teach. The problem it seems is the lack of a particular *structured* method for success. These reforms add costs to staff development (training teachers in new structured methodology) but again they are relatively cheap reforms and the factory structure is preserved.

More difficult to implement and, therefore, more costly to reform are alterations to the factory structure itself. Reforms of this type include: special education and alternative education programs, to fix broken products; block scheduling and year round schooling, restructuring the factory timetable; school vouchers and charter schools, change factory financing. Under any of these reforms the factory does change its structure somewhat, but it remains a factory. Even home schooling, though seeming to replace the factory completely, only moves factory production to a domestic setting. The conveyor belt may be more product-friendly, but it still is rigidly mechanistic.

These have been the reform processes undertaken by business and religious leaders, as well as legislative reformers and educators, throughout the twentieth century. After reflecting on the reforms introduced at this high school during the past twenty years, I asked, "Was anything really re-formed?" Aside from superficial differences, this school operates virtually the same way it did twenty years ago in spite of innumerable reforms instituted over the last two decades. Factory model thinking continues and the bureaucracy plugs along. The *form* of this school remains

fundamentally untouched, but the system has crumbled over the years under the pressure of maintaining the factory illusion while continuing to ignore the *patterns* keeping the system alive. The factory model falls apart when you realize the products you are assembling talk back and have mind's of their own. Henry Ford didn't have to contend with products hurting each other's feelings, or bringing in problems from home. If schools were truly linear systems, these reforms would effect greater change.

Rethinking Power, Predictability and Control

When I looked more closely at the actual high school classroom from a non-linear perspective I began to understand why traditional reforms did not *re-form* anything. The reality is that in the high school, predictability and control continue to exist only in the dictionary. They are linear terms that simply don't apply to any real, non-linear classroom I observed. The modernistic notions of control become completely distorted when viewed through the lens of chaos and complexity. From the perspective of the new sciences, control in the traditional sense, can be counterproductive in schools. Control based on a linear model of schools views chaos as bad and something to be avoided. In a non-linear model, however, forcing a system to avoid chaos by repeatedly following a defined path leads to stagnation. Whether imposed externally, as with limit cycles from the district office, or internally, as when a student sets a personal limit cycle ("I can't do it"), controls steer the school and individuals within them away from evolution, sending them toward equilibrium and extinction.

The notion of power is related to control and predictability in a traditional, linear sense. Briggs and Peat (1999) see our modernist society as obsessed with power:

> ...the power of money , the power of personality, mind power, computing power, organizational power, political power, the power of love, the power of sex, the power of youth, the power of religion, the power to change our genes or our self-images, firepower, ...the lives of the powerful - how they exercise power and whether they are gaining or losing it. We have become inculcated with the idea that if only we had enough power we would be free to do and be what we want. We believe that if we had the power to control the situation, we would feel more secure... The truth is our obsession with power may be simply the symptom of our sense of our own powerlessness. (p. 36-37)

The new sciences of chaos and complexity give us a different way to view power and powerlessness. The power of subtle influence within each individual is exerted within the *patterns* of the school. This is the power that *changes everything.* There is a misconception that *control is power* in schools. Because of the non-linear nature of the *patterns* of relationship and interconnection in schools, modernist notions of power and control are transcended. Mandated *control* factors may stifle creativity and spontaneity, but generally they *control* nothing.

The reason we fixate on power and control issues in education is because of our modernist notions of order and chaos. Modernists cannot accept a universe that is unpredictable. Modern science is based upon the metaphor of the clockwork universe; life is mechanical. If we take the universe apart, and study it piece by piece, we can

understand, predict, and control our lives and everything in them. The high school is built upon the foundation of modernism. Educators are compelled to run their classrooms by the clock and by the book. Departures from the prescribed routine are unnecessary and potentially disastrous. Why? Because we might lose control, and control is seen as vital.

As I sit, surrounded by the data I have collected, and the insights I have gained from this journey, in the final analysis of my data I can only declare the modernists are wrong. The high school is not a factory, it is a dynamic, non-linear, self-organized system of infinite complexity and creativity. The high school continues to exist *because* of its unpredictability and uncontrollability, not *in spite* of it. The *patterns* of this system continue to breathe new life into it moment by moment, even as *structure* remains the same. In the high school nothing can be fully comprehended in isolation. Everything is related and interconnected, everything matters and everything changes. The high school does not simply adapt to survive. Somewhere, within the complex webs of relationship and interconnectedness, transcendence evolves.

Chapter 5

What is the experience of seeing a public high school through the metaphors of the new science of complexity? In this chapter, final conclusions about the findings of this research question will be drawn, and the significance of the heuristic method to this study will be explored. The findings of this study will be related to studies described in the literature. Finally, recommendations for educators and reformers will be provided, and topics for further research will be suggested.

Conclusions

Developing a postmodern approach to the study of education is challenging. The heuristic model offers a research tool through which one might see education in a new way. By attempting to view a high school heuristically, through the metaphors created by the new sciences of chaos and complexity, I found *illumination* in a number of areas. However, an attempt by a particular individual to find a particular understanding, within a particular place, during a particular period of time is a search for *an* understanding rather than *the* understanding of the phenomenon. In this regard, the heuristic method lends itself to postmodern studies. The experience of one individual provides a description from a slightly different perspective. The more description, the richer the portrait. Each slice of life that we *can* see, brings us closer to an understanding of the whole.

The value of this study is as another perspective. However, though others may benefit, by far the most significant value of this study has been to me, the researcher. The heuristic method honors the individual voice. The value of one voice is immeasurable, but it cannot represent all aspects of the whole. To say these

experiences fully describe the high school is to ignore the significance of other voices and other ways of knowing. It takes the qualitative description of *patterns* and the quantitative explication of *structures* to holistically comprehend a high school. Above all, this method allows an individual to find personal meaning within a new paradigm. Heuristic research is subjective – the researcher cannot be stripped from the research. It is postmodern in nature. Moustakas (1990) reminds us of this when he states, "I am creating a story that portrays the qualities, meanings and essences of universally unique experiences" (p.13).

When I began this study, I was apprehensive. I feared I would find nothing worthy of discussion. Insecurity plagued me as I fretted about the validity and reliability of what I was finding. I realize now that my trepidation was merely the clockwork of modernism ticking in my head. I distrusted what I knew and intuitively felt. I do not know when I learned to discount my own ways of knowing. Today, I am satisfied and confident this method allowed me to understand the high school in a deeper, more meaningful way. Upon reflection, I see the seeds of this study were planted years ago, the question formulating itself within my tacit knowledge. In my earliest papers the origins of this quest appear. As I struggled to name it, I moved *with* my instincts, catching glimmers of insight and illumination as I sought greater clarity.

Socrates urged his pupils to know *themselves*. They might have benefited from the introspective quality of this approach. Incubation and immersion have enabled me to know *my*self far better as I proceeded on my quest to know the school. The holistic quality of this quest forced me to envision interconnections and relationships from within myself as a vantage point. In a sense, I became the viewer

and the viewed, the researcher and the researched. I understand now that I can only understand the high school from my own unique perspective. Though my point of view is unique, it has value in the holistic interpretation of the school. It is only one of many voices that make up the choir, but without this voice something is changed. Likewise, I acknowledge that I cannot know anything until it has filtered through me. Every paradigm filters individual perceptions, but every unique experience filters perceptions yet again. No research is completed before it filters through the researcher's own perceptions. This method simply and honestly drops the pretense of objectivity.

Immersion, incubation, and illumination refined my understanding of the learning/knowing process. By *naming* these aspects of the process, I developed heightened awareness of the process within myself as I came to know. This methodology enabled me to be aware as my insight developed. Rather than disjointed steps, immersion, incubation, and illumination are interconnected, making it impossible to identify where one stops and the other begins. Like a hologram, they are enfolded within one another, both rising and submerging. This experience has been of great personal value to me in many ways. I *know myself* far better now than when this quest began. As a classroom teacher, I have not often had the leisure or purpose to intensely focus on what I do or what I *know* about what I do. The heuristic methodology allowed me the freedom to explore issues that were relevant to me. In addition, it helped me to see the connections between what we experience and what we know.

Within the tenets of chaos and complexity, all matter has purpose and power greater than that of a cog in a machine; the universe exists within all, as all exist within the universe. Everything is separate and unique, while being a part of and having influence over everything else. It is a science whose descriptions sound contradictory to Newton's student, but at the deep, quantum level of scientific examination, it is the contradictions of chaos and complexity that knit the universe together. When chaos occurs in the Newtonian universe, it is seen as an aberration - something gone awry. Chaos theorists, however, view periods of turbulence as normal and necessary to our survival. The universe could not have developed without it, and systems that attempt to subdue it, die. Order does not free us from chaos. Rather, it is chaos that brings us order. For myself, I must acknowledge that the mechanical clockwork still ticks in my head. As a teacher, I must be constantly aware that the factory perspective still drives the high school. Like viewing optical illusions, I have to remember to shift my focus to see the forest *and* the trees, the figure *and* the ground, the lady at the vanity *and* the human skull. This requires a postmodern willingness to accept the inconsistencies of living in a world bound by interpretations from an out-dated world view, while simultaneously perceiving life through a different and individual lens.

Despair rooted in separated disciplines, information without meaning, and passive students can be seen anew by shifting focusing to the organic, interdisciplinary patterns of interconnections and relationships immersed in context. Thinking reliant upon clock-driven planning, external discipline, and focused on training, can be *re*-viewed with respect to spontaneous, internal development focused

on transcendence. We can rise above artificial, memorized minutia by enveloping information in conversation and reflection in the context of people's lives. The old world view values test scores and grades, but the significance of personal satisfaction and judgments of worth cannot be ignored.

As an educator I must learn to look at the larger (and for me) truer picture. I must learn to see myself and my students within the context of the world in which we live. Subtle influence has the power to change individuals and systems. I am not alone in my efforts and I must continue to be open to the continual flow of interconnection and relationship as I struggle to evolve and transcend. I must trust the order in chaos.

I understand that no science is exact. I can never see a complete and exact portrait of a high school, even if I limited it to one particular moment. I must be satisfied with an illusive, out of focus snapshot. Even as I view it, it vanishes. Describing a high school is akin to describing a river. It appears to run within definable boundaries, moving the same water the same way, day after day. Closer inspection suggests that the river never runs at the same speed or carries the same volume of water. Its path changes by the moment. Sometimes the river is noticeably different, far from equilibrium, as during drought or flood. Rivers are dynamic systems that can only be understood approximately and in relation to time and space.

So it is with high school. The potentiality of chaos lurks in the background. Although chaos is natural, it is not predictable. I can understand a great deal but I can never understand all that is the high school. I must learn to live with mystery. Everything cannot be known. I have to accept *not* knowing. I must be able to live

without the comforting illusion of prediction and control. I must see and *be in* the world as it is, not as I would have it. The new sciences of chaos and complexity tell us that a world completely known and controlled does not and can not ever exist. Additionally, the new sciences remind us that our own subtle influence might be felt far beyond the time and space of our personal existence. As I end this quest, I return to the words of Gill (2000):

> It only remains to be said that we are not participating in this dance of cognitivity as individual knowing agents. Rather, the dance must be seen as a common group effort on the part of the entire human community. Thus, we are dancing in a large circle, joined through out respective embodiments, to each other and to the surrounding world. Sometimes we agree on the proper moves to make, and sometimes we do not; sometimes we agree on the nature of reality, and sometimes we do not. But by means of our common dance, we can and do correct our views and come to a knowledge of the world, one another, and even ourselves. (Gill, 2000, p. 50)

Study Findings and Related Literature

The purpose of this journey was to *see* the high school from a new science perspective. I feel I have done that. Remarkably, though they had limited exposure to these tenets, the people I spoke with along the way echoed many of my own feelings. It was amazingly difficult at times to decide whether an example applied to one tenet of the new sciences or another. It was not until the end that I realized why: the mechanical clockwork still ticks in my head. Human experiences are multidimensional and cannot be explained by only one tenet. They can only be fully

understood holistically, which requires complex explanations. The science of chaos and complexity provided me a language with which to formalize my thoughts. Intuitively I have felt things I couldn't explain. I had a personal need to understand. The second thing that surprised me was that by focusing on virtually any of these tenets, I would return to the same themes: holism, everything is related and interconnected, everything changes and nothing changes, everything matters, and our mistaken interpretations of power, predictability and control.

Unfortunately, in the literature there really has been no study quite like this one for use as comparison. However, there are numerous studies (Akbaba, 1999; Cutright, 1999; Dowson, et al. 1999; Fleener, 2002; Guess et al, 1993;Gunter, 1995; Harvey et al., 1996; Livingston, et al.,1998; Reilly, 1999; Smith, 1995; Sullivan, 1994; Wertheimer, 1997,1998) that advocate the use of metaphors from the new sciences of chaos and complexity when studying education as does this study. In addition, these studies, like mine, tend to view schools as organic, self-organized non-linear systems.

While studying two elementary schools, Livingston, et al. (1998) identified recurring patterns of non-linearity, sensitivity to initial conditions and feedback loops in both schools. These were metaphors I found useful in my study as well Additionally, they found similarities and differences within the patterns of each school. "The patterns within these recurring patterns indicated that one school was not a replica of the other" (p.11). Nevertheless these researchers conclude the schools had far more similarities in patterns than differences. What I found might suggest that these schools had similar structure and different patterns. This is evidence that

structures vary little (nothing changes), but differing patterns (everything changes) can develop quite different school environments.

Speaking to sensitive dependence on initial conditions they found, "each school is different initially and because one can never know all the variables in the beginning, one school cannot move in the exact direction as another" (p.14). In my study I found this to be the case also. Furthermore they found that, "The systems of each school fed back on the school, enfolded all that had happened, magnified slight variances, encoded in the systems memory, and prohibited prediction, thus making each school different" (p.14). This description sounds very much like the feedback, bifurcation points and irreversibility described in my study. This description also generates a fractal or holograhic image of infinite change within a limited space, similar to what I described.

Reilly (1999) in studying European schools found that non-linearity foiled linear development planning in the schools he studied. "...the development effort is most likely to be a disrupted, uneven, unpredictable, and uncontrolled process because of influencing factors that cannot be foreseen ahead of time" (p. 437). I found this to be true through out the public high school. This creates the power and control issues that were evident from my study. In addition Reilly concludes that the chaos inherent in education systems can be a good thing. "A final implication is that it is not necessarily bad to have a chaotic educational system. Chaos, as used in non-linear theory, does not mean a random set of behaviors. It does mean that the behaviors displayed are cyclical and non-repeating, responding to permutations in the system that may not be discernible" (p. 438). I agree with Reilly. I found chaos to be the

creative force that keeps us from extinction. By understanding turbulence from the vantage point of the new sciences, power and control must be re-thought and limit cycles can be avoided.

Due to the non-linear nature of schools and the unpredictability of change introduced to the system, Sullivan (1999) warned that, "When considering the implementation of a policy by a school community, a single creative impact could send repercussions throughout the entire organisation (sic)" (p. 414). I found this to be true at this high school. It simply was not possible to predict where the repercussions of perturbation or change might be felt. Additionally, he found the complex interconnections that became apparent when looking at the school holistically. "The lack of ability to predict long-term situations in social systems stems from the fact that human behaviour (sic) consists of continually making new decisions about our world with each new experience" (p. 420). This last statement suggests the presence of both bifurcation points and the continually changing patterns of relationship and interconnection evident in my own study. Likewise, change in the patterns of relationship speaks to the concept of *everything changes.*

Chen (1998), in her studies with clients in psychology, found that chaos was beneficial in moving the human systems toward transcendence. "For many people, however, the chaos....is a pathway toward self re-organization...disorganization and turbulence are not necessarily disorders and disease. Rather they can be states of maximum readiness for a more advanced self-system to emerge...The edge of chaos, as a precursor of new order, is transformative and adaptive" (p. 11). I think this

concept, when applied to the social system of the school works in similar fashion and is similar to Reilly's (1999) opinion that chaos is healthy for schools.

Finally, because this study is unique in its methodology and format, it can be stated that these findings are unique to my experience of them. Still, the results of this study are consistent with studies found in other social sciences. Wheatley (1992) found comparable examples when applying the tenets of chaos and complexity to the field of leadership. Corresponding findings can also be found among the examples used by Briggs and Peat (1999) when describing the new sciences as they are found in the larger society in general. Their works, like mine, find the metaphors of the new sciences of chaos and complexity appropriate and useful in describing both human behavior and human systems.

Recommendations

Recommendations To Teachers and Administrators

Many years ago, as a young and inexperienced teacher, I was fortunate enough to work with a principal whose influence has affected my entire outlook on teaching. He perceived education from a purely experiential and intuitive point of view. His philosophy was simple, and it has guided me and many others over the years. It has never let me down. Throughout this study I have been reminded of his advice time and again. He was realistic when it came to directives from the district office. He did not pretend that as educators we could or even should follow the directives of politicians, reformers, or central administration directors. If we were forced to do something ridiculous, he would admit it and find a way for us to do it as unobtrusively as possible. Always, he reminded the faculty that we were there to help

students. Whenever he was approached for advice as to how we should proceed, he would remind us, "If it is good for students do it, if it is not good for students don't do it". This was the main consideration in all decisions. If a teacher felt something needed to be done differently than policy allowed, a way would be found to do it. If students were being negatively affected by a district policy, a way around district policy would be found. It did not matter if something was good for teachers, administrators, politicians or parents. Their needs were either secondary or irrelevant. For him it was that simple; do what is good for students, and do not let anything stand in the way of that goal.

That philosophy is simple, but it is not easy. It requires fighting the battles necessary to maintain that philosophy. You have to do what is good for students *first*, before considering yourself, your school, or your district. It is also worrisome that you might not get it right. Sometimes you do get it wrong. If so, you must stop and do what is right. Amazingly, students understand this. What you actually do is less important than their belief that you are trying to do what is good for them. It is more important that *you care,* than that you are always right. It is difficult to live this philosophy, but when this becomes the focus of a teacher, important changes begin to occur both inside and outside the classroom. Subtle influences begin to change things that seemed to be unalterable. Can this philosophy change a classroom? Yes. Can it change a school? Yes. Can it change a district? Yes. I have witnessed this process many times.

Why does this work? During this investigation, an explanation came to me. It works because it is a *holistic* approach. It does not prescribe a specific, linear step by

step progression, or a recipe for success in every contingency. It simply gives everyone a similar direction to follow. It implies that each person will find different situations along the way, and when they reach bifurcation points they will steer themselves along the path of what is best for students. This is not a limit cycle. It is open to the flow of change. In addition, it unites the efforts of everyone within the school. Everyone is headed in the same direction, though they may all get there on different and unique paths.

Too often in schools, supervision is interpreted as *control*. We have seen that the misapplication of linear control in non-linear systems is counterproductive. From a non-linear perspective, there is no control over anything in schools. Yet, linear expectations drive teachers and administrators to spend a good portion of the day trying to control people and events. *Supervision* means having *vision* beyond that of others. By focusing on *supervision*, or seeing beyond, my former principal gave teachers a way to *see beyond* the current challenge. The *big picture* he created acted as a strange attractor, pulling in people, ideas, and events. Everyone and everything became a part of the school's pattern. No one was isolated or separated from the whole. Everyone could envision himself or herself as part of the united effort to do what was good for students. They moved in the same direction yet were free to create their own plans for the journey.

As teachers and administrators we need to find the strange attractor that will give our students and staff such a vision. In doing so we should heed the understandings we get from the new sciences. The organic view of the school existing within the larger society, world, universe, must replace the factory model, if no where

else than in our own perceptions. Modernistic leaders who create and enforce *The Plan,* will lead the school only to stagnation. Leaders who instill shared vision lead schools to transcendence. Domination, control, and rule by hierarchy are ineffectual in non-linear systems. However, self-organization allows for the creative participation of the entire system and the subtle influence that nurtures and sustains the whole.

As educators we must work to change legislation that is bad for students, even when it seems our voices are not heard by the legislature that directs us. Until we can change the laws, we must do what we have to do by law, while doing what we know is right for students. We must look for the holistic context that will enable us to teach mandated pieces of information on which students are tested. We must remain child-centered while the legislature continues to uphold curriculum-centered accountability. We must teach meaning more than memorizing, and focus less on content and more on context. In our classrooms, we must not be *fact-happy*. We cannot detour a child's future with minutia. The information we teach is less important than the inspiration we instill in students. We must remember that time is relative in schools as it is elsewhere. Learning is not bound to the clock or the classroom and not all time in school is spent learning. Often it is not as important what we say, as how we say it. Whatever we say or don't say *matters in the life of that child.*

As teachers we must remember that a child is far more complex than we can ever witness. We need to view the student as the person they are becoming, with a past, present, and a future. We need to recognize that we play a relatively small role in the lifetime of this person, yet our influence can be tremendous and not always positive. Students come to us as potentialities. We must try to help them explore

possibilities. The importance of improving standardized tests scores pales in comparison to the real duty we have. We must ask ourselves constantly "How can I help this child live a good life on this planet?" We need not let media, legislatures, or critics deter us from that task. Above all, we must remember we are in the classroom to help children develop the rich interconnections and relationships needed for their survival and transcendence as they go through life *being human*. We must do what is good for students.

Recommendations to Reformers

Those who would reform schools do so for many reasons. Often those reasons have little to do with making education better for the child. For the most part reformers of the past two decades have focused on the substantive *structure* of the schools rather than its *patterns*. They have dissected the system and analyzed its parts suggesting changes in many structural aspects. In contrast, patterns have rarely been acknowledged by reformers, presumably because they are either considered unimportant or cannot be controlled.

Reformers of the past two decades have wrought far more damage than repair to the public high school. The teaching profession and individual students have paid the price of these experiments. At some point, the public must recognize that it is reformers themselves who are responsible for many of the ills in public education today. Reformers, often basing their decisions on unreliable and untrustworthy data or questionable assumptions, have spent billions promising quick fixes and imposing ridiculous standards on schools. Perhaps to ensure that the reformers of education are what they pretend to be, they should be held accountable for the reforms they enact.

The reformers of the past two decades have by and large botched the job. They should be exposed for their disregard of the effects their reforms have had on the human beings we educate. Perhaps when reformers are held liable for the damage they incur, sensible reform will be studied. Accountability should not be confined to public classrooms.

If we are to witness serious, legitimate efforts to improve education, we must begin to envision schools from the perspective of the new sciences. Likewise, the reformers who envision the schools should believe in the future of public education, and sincerely hope to improve it.

Need for Further Research

Dynamic interconnections and relationships abound in the high school. I have discovered patterns and themes that, although not likely to be replicated by other researchers, might offer a starting point. The observed dynamic and interconnected relationships of the high school are unique to me. They do not lend themselves to quantitative analysis or to universal generalizability, yet similar structures and patterns exist for other individuals, in other places. Certainly I have not described all the behaviors of a high school, nor have I applied all the tenets of the new sciences in this study.

My quest to understand the nature of chaos as manifested in this school has helped me to understand that non-linear, self-organized systems will always thwart linear reform efforts. By examining the school through the perspective of chaos and complexity, it becomes obvious that we cannot control or predict non-linear elements in schools. Ignoring these ideas is irresponsible and dooms future reform efforts.

Research is needed in this area to help us work *with the patterns of relationship and interconnection*, instead of against them.

Educators need further research to better understand the patterns, rather than the structures, of a school's system. Research is needed regarding the utilization of feedback loops, as well as how to identify and foster positive influences in the learning process. Most of all, we need a new way we to envision our educational system. Clearly, the linear factory model is obsolete. A new metaphor is needed that includes the forces of self-organization, non-linearity and the interconnections of complex relationships. Ultimately in educational research, we must study the patterns of *effects* of reforms on individual students. Before new reforms are enacted, research must make the case that arbitrary and inconsequential linear changes have left serious and destructive scars on the landscape of education and the students we serve. Because *everything matters,* we are all accountable, educators and reformers alike.

Final Words

During the past several weeks while completing work on this research, I realized that this quest is far from over. It is, and will continue to be an ongoing and lifetime learning process. Once practiced, the reflective nature of heuristic methodology has engaged many aspects of my life. Sometimes, I feel as though I have tapped into a powerful tool for thinking about my world. This method offers a natural and genuine way to engage tacit knowledge. By naming the steps, I have formalized something that I have informally used throughout my life. Without conscious awareness I have previously experience the power of immersion, incubation and illumination. I believe my familiarity with the process will continue to

develop, becoming an ever more powerful tool. I encourage educators to look to this methodology as a way for understanding not only their schools but their own unique lives.

Perhaps the most important insight derived from this research is that as a classroom teacher, I do not have to wait for reformers, or legislators, or administrators or fellow teachers to improve education. Simply viewing what I do in a new, more holistic way can transform the process of education for myself and my students. In reality, no one else can make those changes for me. I went into this research sensing the implications of the butterfly effect would produce profound findings. Instead, I now believe that the concept of pattern and structure (everything changes, while nothing changes) is the most penetrating notion I have found. For those interested in reforming public schools, perhaps this is the place to start.

This journey was initiated several years ago by a chance reading about the new science in the work of Margaret Wheatly (1992). It is only fitting that I bring it full circle today with her inspirational words.

> ...we need the courage to let go of the old world, to relinquish most of what we have cherished, to abandon our interpretations about what does and doesn't work. As Einstein is often quoted as saying: No problem can be solved in the same consciousness that created it. We must learn to see the world anew. (p. 5)

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