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Science as a Story

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SCIENCE AS A STORY

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INTRODUCTION

As the bell rang one Monday morning a few weeks ago, I observed my students as they slowly started trickling into my first hour biology class. A few sauntered in the room with tired, droopy eyes, their minds slowly processing the morning's events while others rushed to my desk lamenting about problems at home, distracted by unfortunate events out of their control. Still others entered enthusiastically, buzzing about their weekend activities, the latest social trauma or athletic conquest. The personality, social, and academic differences among my students were blatantly obvious, and most seemed to have little in common besides age, the challenges of adolescence, and their presence in my science class. Beneath the surface of those differences, though, an insidious and challenging similarity connected my students. For a variety of reasons, most of my students cared little about learning science.

Science—a word that elicits feelings of fear to incredulity to failure is the core focus of my teaching. And as indicated by the students in my classroom that morning, it is rare to find students who naturally seem to love science as a school subject. Most regard science as a means to an end—a class to endure to graduate from high school or to meet college admission requirements. Some students really do not have any idea why they are in my science class—science seems so disconnected from their daily lives that they consider it to be a meaningless waste of time and energy. If questioned, I am sure some students would even use the words "dreaded" or "boring" to describe science as opposed to "challenging" and "exciting." Regardless of the students' reasons for their dislike of science, the outcome is the same: Very few students seem thrilled to be in science class.

It is difficult to imagine why a young person would dread going to science class when one reflects on the beauty, immensity, and complexity of the natural world. The world abounds with splendor—incredible displays of color and intricate patterns are common occurrences from the depths of the sea to the galaxies in the sky. The precise simplicity of the way molecules interact with each other and form structures that support all of life is mind-boggling. The words used to describe science and the world should be "incredible," "breath-taking," or "magnificent;" boring does not even come close to accurately describing the world around us. In fact, it is so inaccurate that it is almost comical to describe a mountain or a coral reef as uninteresting. Somewhere between the world of science and the students' perception of the natural world as transmitted through science class, the true essence of science has been lost. What has happened between the world and the way it is perceived that has so distorted the message?

The question may arise as to whether the world I am describing actually relates to science and thus, science education: Is science about seeing the beauty in nature and appreciating it or is it only concerned with processes and concepts? *Webster's*

Dictionary (1997) defines the word science as "a branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws" (p. 703), and that seems to be the understanding of science that has permeated science education and been infused into the minds of students. If *Webster's Dictionary* is correct, science is simply "a body of facts or truths" coherently organized and revealing the processes that underlie the natural world. But is that all there is to it? Were the great scientific minds of the last thousand years driven by a pursuit of facts? Did Einstein, Newton, Curie, and Fleming simply seek to memorize facts or were they driven by higher aspirations?

A perhaps more accurate view of science would be a journey and of scientists as explorers. Traveling through uncharted territory, often surrounded by perils, plagued by failures and seen as outcasts of society, scientists persevered in the pursuit and thrill of discovery. Dyson (1995) described science as "a mosaic of partial and conflicting visions" tied together by a common thread—the "rebellion against the restrictions imposed by the locally prevailing culture" (p. 1). Driven by a dream, sometimes spurred on by a rebellious spirit, science entails much more than simply facts, concepts, and processes.

Whether or not science is truly a formidable pursuit can be established by looking at the lives of past scientists. Many faced incredible barriers, had to forsake family and society, and never enjoyed the fruits of their labors, yet they were driven to explore. What is it about science that drives ordinary men and women to such lengths?

Haldane (cited in Dyson, 1995) commented on the facets of science that make it so irresistible.

> First, it is the free activity of man's divine faculties of reason and imagination. Secondly, it is the answer of the few to the demands of the many for wealth, comfort, and victory…gifts which it will grant only in exchange for peace, security and stagnation. Finally, it is man's gradual conquest, first of space and time, then of matter as such, then of his own body and those of living beings, and finally, the subjugation of the dark and evil elements in his own soul. (p. 4)

In addition, many scientists of today would probably agree that the possibility of wealth and fame drives them to a certain extent, but more importantly, that the "chance of catching a glimpse of the transcendent beauty of nature" (Dyson, 1995, p. 10) lies at the heart of their endeavors. The natural world and its workings are to a great extent beyond the realm of human design and even comprehension—forces much more powerful than the human mind have shaped the earth, its processes, and beings. Money and prestige can only motivate to a certain extent—the fulfillment that comes from these gains lasts only a little while, but transcendence is timeless. Being a part of a larger cause has motivated people to do great things since humanity began and continues to drive scientists today. Unfortunately, transcendence is rarely something addressed in science classes; more commonly, a finite, simple belief of the natural world is conveyed.

While a transcendent beauty lies at the heart of science, rooted outside human experience and untouched by human hands, it has also been described as a "living enterprise" (Swartz & Fischer, 2001, p. 303). It encompasses many aspects of human life and intertwines knowledge with the application of that knowledge for practical purposes. Just as there are lessons to be learned from history, there are lessons to be learned and applied from the study of science. It is not a stagnant body of facts, but a growing ever-changing entity. While most would consider science to be a close relative to the field of philosophy, a rational investigation of truths, Dyson (1995) described science as actually being much closer to art, stating that "it is more construction" (p. 8) than investigation. What aspect of science is being conveyed in most classrooms?

The humanity of science is often the most ignored component within the field—but without a human context, science cannot exist. Just as knowledge without context is meaningless, so is science without humanity. While it is inarguable that the world would continue to exist without humans, the body of knowledge we have about science is the result of thousands of individuals studying, asking questions, generating ideas, and stumbling upon revelations about how science works. And other individuals are regularly transforming the body of knowledge that currently exists as they explore the world. A fact is simply a fact—inert knowledge—but science is shaped by facts that when connected to human contexts have significant and ever evolving meaning—a crucial aspect of learning. The humanity of science naturally intertwines meaning in the process of learning, and as Egan (1999) stated, "Students can most easily resuscitate knowledge if they learn it in the human context in which it was first generated or discovered" (p. 51).

Science is also alive with imagination. While most students view the imagination as something to be used only in the context of the English classroom, the best scientific discoveries developed because someone was imaginative enough to think differently about the world. Newton certainly had to use his imagination to think about the laws of gravity and motion—such thinking was novel and had never been done before—he did not have a book to guide him in his thinking; all he had were the unique powers of his own mind and imagination. The concept of relativity is mind-boggling to understand, but the fact that a human, Einstein, developed the complex theory is even more incredulous. Certainly imaginative and innovative thinking was involved. Is the creative aspect of science ever conveyed in science education? Bruner (1986) contends "science proceeds by constructing worlds . . . by inventing the facts against which the theory must be tested . . . " (p. 14) and obviously Einstein and Newton had to "construct worlds" to imagine how their ideas could possibly fit into the real world. Is science education developing the imaginations of young people or deadening them?

The students that entered my classroom that morning had obviously received an inaccurate message about science because a desire to actually learn about and participate in it was glaringly absent. Who in their right mind would not volunteer to take part in an uplifting adventure to discover the magnificence of the world? What child would not want to use his or her imagination to try and discover the way things work? Yet daily I face defiance from my students and a reluctance to engage their minds, which create a constant roadblock in my teaching endeavors. The reality of the situation is disheartening; it is difficult to think of one's life calling as simply another person's means to an end or an obstacle to be endured until a passing grade is accomplished. The only remaining hope I have lies in the fact that I also know that somewhere in the heart of my students lies the essence of science—sometime in their past they too have marveled at nature, life, and cosmic forces.

It seems that not until a child has reached a certain age, somewhere between the upper elementary years and high school, do they develop an aversion toward science—such a dislike appears nonexistent in young children. Babies are not born with an inherent dislike for science, but somehow through the formal schooling process, science became the enemy. A reflection on young children, toddlers, and even elementary school children reveals that a fascination with nature and science is natural. Before these young individuals even have an idea of what science as a discipline is, their minds seek to know the "hows" and "whys" of the operations of the world. Anyone who has spent time with young children has heard questions about thunder, rainbows, flowers, baby animals, and fireworks flow from the mouth of a child—a young child's mind is filled with wonder and curiosity about the natural world.

Unlike much of what is experienced in school science, the aim of a young child's questions is not to increase knowledge or search for inert information—inadvertently children recognize the greatness of nature and seek to somehow become a part of it, but to reach the end of the rainbow, to trace a bolt of lightening through the sky, or to care for baby animals. In contrast to the mass of scientific information that is thrown at students in school about science, a child's questions and desires hint at the true essence of science; for them, the message has not been lost and mangled beyond recognition. The clear message for a young child, and one he or she unintentionally understands, is that the most important and endearing quality of science is its transcendence. Unsuspecting children have tapped into the transcendent nature of science through their inquiring minds—they have yet to be lulled into deadness by unsuspecting parents, teachers, and other adults.

It is strange to think that parents and teachers, people who desire to inspire and shape the future, contribute significantly to the deadening of children's minds regarding science, but their role in the process is unquestionable. Many knowledgeable parents and teachers have responded to questions about rainbows and the color of the sky with an explanation involving water vapor in the air, light waves, and refraction. And many children have felt their hearts and hopes sink to hear such a simplistic explanation. While the explanation is scientifically accurate, the child was hoping to hear something mysterious, filled with wonder and excitement. They had hoped to hear about angel's wings or the ocean in the sky, not light and water, such familiar terms.

By the time a child is a teenager they have heard so many simple explanations that their minds are no longer filled with wonder, awe, and excitement. Though the beauty of the world remains unchanged, a slow, insidious deadening of the heart takes place as a child grows, so that by the time they reach high school most young people, my students included, care little about science and have even developed an aversion to it as a course of study. It seems that the very tool used to develop young scientists and inspire children about the natural world, science education, is actually having the reverse effect; incredulously, the message of science is erroneously being translated through science classrooms.

The situation has developed into an unnatural state of boredom for many middle and high school students; for too long they have been given sequential, simplistic answers to their heart's questions and the result has been devastating. Science educators, myself included, have given precedence to the knowledge of facts and concepts, leaving the heart and essence of science behind. In the commandeering pursuit of knowledge, we have plowed through the curriculum, leaving the mangled corpses of wonder, mystery and awe in our wake.

Not only is science education disturbingly misrepresenting science, but it also seems that many children have a significant lack of understanding of science related topics and concepts. Daily I witness children who can answer simple questions about science, but when pressed to look beyond the surface, I receive many blank stares. While these children have the ability to retrieve information, does that signify real understanding? Wiggins and McTighe (1998) described six "facets of understanding:" explanation, interpretation, application, perspective, empathy, and self-knowledge. These facets pertain to levels of understanding that are much more than information retrieval; a wide array of skills are involved. Perkins (1991) similarly noted that understanding goes significantly beyond storage and retrieval—but those are the skills many children leave with after completing a science education program.

In reference to biology, being capable of describing the stages of cellular respiration is quite a feat, but without an understanding of the role it plays in a cell, an organism and the cycling of matter in an ecosystem, it is meaningless nonsense. Just such knowledge is common within science as Perkins (1991) noted, "Researchers have found that students have a strikingly superficial understanding of what they have been taught" (p. 9).

In addition to a lack of understanding, students also seem to have inadequate views of the *nature* of science. Current methods of instruction have taught students that science is completely empirical, objective and represents absolute truth, but Roth and Lucas (1997) argued such an approach is problematic:

> First, views of knowledge as factual and objective are inconsistent with recent research in science studies . . . in which knowledge was characterized as systems of discursive and material practices evaluated on the basis of their situated usefulness rather than in terms of their truth value. (p. 147)

Objectivity is certainly a foundational aspect of science, but contextless objectivity is not educational—it is ignorant.

In lieu of developing understanding, science education has focused on facts and processes, so it would seem reasonable that the children of the United States would excel at such tasks. Unfortunately, that is not the reality; the recent "Trends in International Mathematics and Science Study" indicate that the children of the United States, while improving upon previous years' test scores, continue to trail many nations in science and math (NCES, n.d.). Our country's future security and prosperity rests with these children and their intellect and hearts. Recent reforms in science education have called for stricter standards and higher expectations, but significant gains have yet to be made.

The mini-crisis faced currently by the United States regarding science education is nothing new. Since the Soviet launch of the Sputnik in 1957, the United States has been scrambling to maintain the competitive edge in science and technology that it has sustained for decades. On the heels of that crushing blow to the American ego, many people believed the problem lay with the educational system and advocated for immediate and drastic changes to the way science was taught. The initial approach, launched in the 60s, was to present science by "focusing on what scientists know" (Yager, 1988, p. 53). Ten years after this shift in education, the efficacy of the approach was in serious jeopardy as Yager (1988) described:

> It had become clear that the premises of this approach were flawed: science as scientists know it was neither inherently interesting nor appropriate for all. Requiring all students to learn such science was proving disastrous. Students could see little use for the science they learned. Moreover, their science study allowed them no scope for using logic or imagination—skills purported to be basic processes of science. (p. 53)

The effects of those reforms are still being felt today, though new waves of change are shifting the direction of science education. The recent improvement in achievement scores offers hope and indicates the slow, painful process of change is worth the effort. Progress is being made, but there remains room for improvement. Increasing test scores are encouraging, but until the heart of science is returned to science education, children are going to miss out on a beautiful, magical world.

The situation I am describing may sound extreme and alarmist and some may question if the situation warrants such concern. While it is true that the world will not stop revolving if young people do not understand relativity or photosynthesis, scientific issues can have a profound effect on the quality of life. Many of the choices people face daily, particularly those in industrial nations, will have a great effect on the future. Even issues as menial as recycling or walking to work instead of driving, compounded over time, can change the face of the planet. These choices require a certain degree of scientific literacy—a skill that is crucial to our country, our planet and our future.

Scientific literacy does not imply that one understands the complexities of gravity, the periodic table or Linnaean classification; Davis (cited in Stepien & Gallagher, 1993) outlined the qualities of a scientifically minded individual:

> We can say that an individual who has a scientific attitude will (1) show a willingness to change his or her opinion on the basis of new evidence; (2) will search for the whole truth without prejudice; (3) will have a concept of cause and effect relationships; (4) will make a habit of basing judgment on fact; and (5) will have the ability to distinguish between fact and theory. (p. 137)

With the increasingly complex issues facing society from the question "when does life begin" to nuclear power, "our future is [becoming increasingly] dependent on how wisely humans use science and technology," (Nelson, 1999, p. 14). Having an abortion or burning crude oil today will affect tomorrow—far too many people are shortsighted in their decisions, living moment by moment, disregarding the implications of those decisions for the future. The destruction of habitat to obtain firewood may seem like a good choice today, but when that destruction leads to the annihilation of hundreds of species, is it the best choice? Do humans want their children to inherit a vibrant, glorious planet full of life, or do they want their children to scrape for survival in a desolate wasteland? Which would most people prefer: a view of Earth from outer space, with pristine blue waters, wisps of snow white clouds, radiant green patches of land or the reddish/brown Martian landscape?

Additionally, there is incredible power within science and technology, and people need to understand the implications of that power. As never before in history, we have at our fingertips the technology to extend the length and improve the quality of life. We have enhanced the nutritional value and productivity of our crops. Hundreds of once deadly diseases are now mere nuisances. The capacity for good in the world is tremendous, but as the nightly news reveals, such a capacity also paves the way for great harm. Bioterrorism and nuclear weapons are two outcomes of great scientific achievements—good information in the hands of some individuals can be deadly and dangerous.

Scientific literacy is becoming almost as crucial to a democratic society as reading and math, but Miller (cited in Stepien & Gallagher, 1993) described the situation in the United States as "woeful" and notes that "only 20% of the U.S. population has the requisite knowledge to be considered scientifically literate," (p. 136). Additionally, concern among leaders in education, communities and businesses has been increasing about the number of high school graduates that lack the skills of a scientifically literate individual: critical thinking, problem solving, and abstract thinking (Ward & Lee, 2004).

It is clear that the current situation within science is serious and that too many people are uneducated about scientific issues and lack a scientific mindset. It is also apparent that these shortcomings are undoubtedly connected to science education—

what is ambiguous is what needs to change within science education. If the outcome of the problem with science education is that it is failing to teach basic content as well as develop understanding, what is the root of the issue? How can so many people be so uneducated about science after participating in years of science education?

Buch and Wolff (2000) suggested that the approach currently being used in many science classrooms leads to superficiality and lack of understanding. Even for students undertaking science courses to prepare for careers in science and technology, much of the information and skills are passively taught through lecture, leaving many graduates without the practical skills they need to succeed in their various fields. A scientist does not become a good scientist only by copying notes and reading from a textbook—a good scientist looks at the world and asks questions about it. Inquiry—a core component of good science—is curiously absent in many science classrooms.

The question that remains, then, is what vehicle can teach students about the world and how it works, while retaining the essential qualities of science? On a surface level, it may seem that I am advocating for a softening of the science curriculum; some may envision classes of teenagers staring at flowers, mountains and bunnies, but that is not what I am suggesting. Science education needs to *deepen* to do the natural world justice. Science deserves a more holistic approach and it needs to be placed in its natural context, including the essential aspects of mystery, magic, beauty and humanity. Science education should teach students about the natural world, while invigorating the marvel in their hearts about the world. Egan (1989) suggested that the "educational achievement is not to make the strange seem familiar, but to make the familiar seem strange. It is seeing the wonderful the lies hidden in what we take for granted that matters educationally" (p. 47).

This principle certainly applies in science because at the most basic level, all matter, living or nonliving, is reduced to atoms—everything is made of the same basic materials—and the simplicity of that fact could be taught in a way that removes mystery and awe or in a way that causes amazement at the fact that the arrangement and interactions of such simple materials create hundreds of compounds, thousands of structures, and millions of living creatures. Similarly, a rainbow should be taught in such a way that it is presented not merely as the interaction of light and water, but as a magical and magnificent event, culminating with a beautiful display in the sky.

I contend that science is a pursuit of epic proportions, involving imagination, rebellion and competition, and culminating with a view of transcendence, but how can it best be conveyed in the classroom? The disconnection between science education and science as it actually is practiced in the world is wide and daunting. It seems almost as if the world of science education has been taken over by invaders whose intent is to distort and blur the practice of science so as to disillusion the very lifeblood we need to keep science going—young, inquisitive scientists. The invaders have attempted to confuse the youthful, curious minds of today into believing that science is no longer a mystery, that there are not any more great discoveries to be made, and that the highest achievements in science are memorizing photosynthesis and correctly applying Boyle's Laws. While the invaders are fictional, politicians, policy makers, lobbyists, and even science educators have carried their message through the vessel of science education. Unfortunately, disenchanted young scientists are a reality, as seen in the students in my classroom, and science education must change to stop further cynicism and corruption of the next generation of great minds.

While previous reforms in science education were less than successful, recent methods have become more prominent and they challenge science education to strive for more than mere knowledge—they bring out the essential qualities of science that make it such a magnificent endeavor. Techniques such as problem-based learning (PBL), inquiry-based learning and the case study method are promising because they mirror science as it is done in the real world. These methods teach students valuable subject matter content, but also educate them on the nature and practice of science—they reflect the humanity and challenges inherent in science. They involve presenting students with a mystery to be solved, something unexplained and puzzling, and require the students to take an active part in solving the mystery, while giving them some stake in the outcome. The success of such methods to amplify content knowledge comprehension, increase critical thinking skills, raise motivation and develop an understanding of the nature of science has been the focus of much attention in recent years and indications are positive. The question remains, though, what is the essence of these methods that make them so promising and potentially successful?

Herreid (2003), in the *Journal of College Science Teaching,* believes that the essential element that ties these methods together and makes them effective in the classroom is that they all involve a story. He stated that case studies and problem-based learning, while seemingly different pedagogies, all "[use] stories with an educational message" (p. 366). The intrigue of stories is not new—they have played a vital role in humanity. For centuries our ancestors told stories to pass along critical information, Plato used stories with his students, and people tell stories about their lives every day. Egan (1999) commented on the important role of stories in culture and knowledge transmission:

> First, the story has been one of the main media for initiating children into the adult world of knowledge and understanding in most places and times. Through myth and story-shaped ritual, or myth and ritual intertwined, the young have been inducted into full membership of their culture. Clearly our educational needs are significantly different from those of myth-using cultures, but the near universality of the story form as the conveyor of the most important truths about the world and experience should provide at least a superficial tug on our attention. Second, we can observe the power of stories to convey information and understanding in a curiously compelling and engaging form. (p. 162)

The social nature of humans makes us uniquely designed to take in stories and tell stories as a way to learn, gain knowledge and increase in wisdom. Milne (1998) wrote, "Stories are an undeniable feature of the human condition" (p. 178). Why science education has failed to more greatly utilize this "undeniable feature" in the context of teaching is unknown. Educational fads and reforms come often, cycling through schools like tornados, dismantling and rebuilding the curriculum, the way teachers teach and what students learn, and yet these fads leave in their wake the need for more reform. Is perhaps the best reform for science education to return to its roots of story telling? Should we return to the techniques used since the dawn of man to develop great thinkers?

The remainder of this paper focuses on the utilization of stories in the science classroom as a tool for conveying the nature of science, developing great thinkers, increasing scientific literacy and more accurately representing science. Many aspects of stories and many methods that incorporate them into the classroom are discussed to convey the diversity and richness of their usefulness and efficacy. The literature review first establishes the appropriateness of stories within the science classroom since many people would reserve most forms of literature, particularly stories, to other educational realms. Some of the different teaching techniques that use a story format are discussed, and the literature review concludes with a discourse on the efficacy of stories for developing content knowledge and scientific understandings.

Chapter III describes my action research project and my attempt to revitalize my curriculum by incorporating stories within my biology classroom. For over 1 month I closely reviewed the participation, energy, and motivation in my classroom as well as student critical thinking. The methods, data, and analysis are detailed at that point. Finally, in Chapter IV, I reflect on the method of using stories in the science classroom, how this has affected my teaching and the learning of my students, and I provide suggestions for future research and application.

Chapter II

REVIEW OF LITERATURE

Advocating for the implementation of stories in the science classroom requires some concrete evidence as to their educational utility and even their appropriateness. Some may envision teenagers sitting in a circle, sucking thumbs, and pulling hair, while a teacher reads fairy tales, and they would laugh at the mere thought of such a preposterous suggestion for reforming science education. Others will probably argue that stories have little usefulness in the science classroom, particularly in secondary and post-secondary education.

This section addresses those concerns, starting with the question, 'What is a story?' Additionally, are stories appropriate in a scientific setting and in what ways could they be used? The concerns raised by high stakes testing, increased standards, and complex content are valid and any change in education should address such issues. So, can stories really help students learn science more effectively? Finally, a prime concern discussed in the introduction was the inadequacy of current methods to present the nature of science; therefore, another question to address is: Do stories more accurately reflect the nature of science or are they another destructive reform on the path of science education littered with the remains of past efforts?

The Definition of "Story"

Before proceeding too far in a discussion on how stories affect learning in the science classroom, the idea of "story" must be understood. Willingham (2004) described the main components shared by a variety of stories, whether plays, movies or novels, and concludes that stories contain four basic features, often referred to as "The Four Cs":

> The first C is causality. Events in stories are related because one event causes or initiates another. The second C is conflict. In every story, a central character has a goal and obstacles that prevent the goal from being met. The third C is complications. If a story were just a series of episodes in which the character hammers away at her goal, it would be dull. Rather, the character's efforts to remove obstacles typically create complications—new problems that she must try to solve. The fourth C is character. Strong, interesting characters are essential to good stories. (p. 43)

Stories are generally structured around these four items, but neatly intertwined within these components is the common thread of emotion. Milne (1998) described the process of creating a story as taking a narrative of events and adding value and meaning to the text and the interpretation of it. The conflict present in stories lends itself naturally to an emotional response, in addition to well developed characters. In any good story, the reader or listener develops an emotional response.

Egan (1989) further elaborated on the element of conflict within stories, referring to the structure of conflict as involving binary opposites. "Embedded in the story or embodied by the story are conflicts between good and bad, courage and cowardice, fear and security, and so on. The characters and events embody these underlying abstract conflicts" (p. 26).

The power of binary opposites to establish meaning in the story and engage the listener or reader is clear because everyone can connect with such concepts (Egan, 1989). Students, regardless of the content, can understand the concepts of survival and destruction or life and death and see the struggles involved in a story within those contexts. Through using abstract binary opposites in teaching, complicated content becomes meaningful and easier to comprehend.

Within the science classroom, stories can take many different forms depending upon the content and objective. Some of the more obvious methods involve directly using the types of stories familiar to most people. Additionally, some methods of teaching, such as PBL and inquiry-based learning, share many of the same components of a story and can be viewed as an interactive extrapolation of a story. Some curriculum reformers have even suggested developing curriculum around the format of a story and integrating the core components of a story (causality, conflict, complications, and character) into lessons. From having children read a traditional story to developing curriculum around the themes of a story, stories have diverse applications in the classroom.

All people are familiar with stories, and the traditional story can be utilized in many ways in the science classroom. Using historical stories to describe the discoveries and great achievements of the past can be a meaningful way to teach content and develop an understanding of the nature of science. Historical stories invite students into the "life of the inventor, discoverer, user, sufferer, or author," giving knowledge a context and connecting it to the lives of real people as well as connecting to students' emotions (Egan, 1997, p. 94). Stories can also be developed and used to describe many scientific concepts such as chemical processes or the adaptations of organisms. By incorporating the elements of a story into such content, students can more easily connect with the new material—the method of communication is familiar to them, so they have less to overcome to understand the content (Willingham, 2004).

In a more abstract perspective, case studies and PBL are also forms of a story. Herreid (1997) described cases as "stories with a message. They are not simply narratives for entertainment, they are stories to educate" (p. 92). Case studies and PBL, at the most basic level, involve presenting students with a case or problem to be solved and asking students to investigate, analyze and determine a solution for the case or problem. Wood and Anderson (2001) commented that case study teaching forces students to look beyond the objective analysis of information and incorporate aspects of cognition, feeling, action and values—all of which are key components of stories. Case studies are simply stories in which the students are invited to play the main characters—the elements of conflict, causality, and complications are already present, and students become star players as the story unfolds.

The most abstract method of using stories in the classroom involves structuring curriculum and lessons into a story format. Egan (1989) was a pioneer in this type of curriculum development and suggested organizing all lessons and activities around binary opposites. Material is presented in terms of these opposites and classroom activities focus on the conflict inherent in binary opposites. In a story, conflict captures the attention of the audience and motivations and actions involved are more easily understood in light of the conflict. The same can be said for using binary opposites in the classroom; everything revolves around the conflict and students can more clearly understand the material they are learning (Egan, 1989). Lesson planning, according to Egan's model, focuses on the "principles of a story rather than the principles derived from the assembly line" (Egan, 1999, p. 163).

A number of science education researchers and writers suggest a similar method of curriculum design, described as a "story line" approach (Stinner, 1995). Such an approach is focused on one central, unifying theme or goal (much as Dorothy wanted to reach the Wizard in *The Wonderful Wizard of Oz,* (1900)) around which characters and events are developed and incorporated into the curriculum (Stinner, 1995). Stinner specifically detailed the components involved in designing curriculum using a story line approach, and suggests the following steps:

1. Map out a context with one unifying central idea that is deemed important in science and is likely to capture the imagination of the student.

2. Provide the student with experiences that can be related to his/her everyday world as well as being simply and effectively explained by scientists' science but at a level that "makes sense" to the student.

3. Invent a "story line" that will dramatize and highlight the main idea. Identify [important events or characters] that may be appropriate to include in the story.

4. Ensure that the major ideas, concepts and problems of the topic are generated by the context naturally. (p. 562)

Using stories in the secondary classroom, particularly the science classroom, may seem to involve a softening of the curriculum, but there are already a variety of methods becoming more common that employ the basic elements of a story. PBL and case studies are certainly not easy tasks for students to undertake in the science classroom, and in many ways they are more challenging than traditional methods. What needs to be understood is that stories do not necessarily take on the form most easily recognizable by the general population—a variety of methods are structured much in the same way a story is.

Challenges

Now that it is understood what is meant by "story," as with any educational method, there are many obstacles to overcome if stories are to play a larger role in the science curriculum. One of the first problems faced by educators is the lack of well-developed materials ready for use in the classroom; it appears that using stories is a rare occurrence in science classrooms (Kim, 2003). Thus, many teachers will be challenged with developing their own problems and stories, and the development process can be extremely time-consuming (Burruss, 1999). Much preliminary work is required in designing the problems and stories, imagining the different routes students could take with the story and devising techniques to keep students on the right track. Additionally, students must be constantly monitored and feedback regularly given (Burruss, 1999). Substantial preparatory work is involved, but the method "is also resource intensive, as there is no single source that can provide all the current information needed to investigate or resolve a situation" (Burruss, 1999, p. 48).

Another common theme underlying the use of stories in science classroom is resistance on the part of the students (Buch & Wolff, 2000).

> Students cannot simply expect to attend class and have a lecture or a laboratory lecture delivered to them or to follow a set of prescribed instructions to conduct an experiment. The challenge of open-ended questions…may at first cause apprehension to many. (p. 106)

Much more is required of students through narratives and case studies than passively listening to lectures or completing worksheets. As creatures of habit, change is difficult for students.

Still others note that stories have done little to positively affect student understandings of the nature of science. Toa (2003) investigated the effect of science stories on the student perception of the nature of science and found that most commonly, the stories served to "confirm and reinforce students' inadequate views" more often than changing their views. It appears that "when studying science stories, many students selectively attend to certain aspects of the stories that appear to confirm their inadequate view; they are unaware of the overall theme of the stories as intended by the instruction" (Toa, 2003, p. 168). On a similar note, Milne (1998) suggested that many science stories, particularly those focused on scientists serve to perpetuate the "notion that scientific knowledge is determined by the nature of the external world and not of human struggle" (p. 181). As such, an "elevated status of science" is promoted, which is deemed unreachable by students.

The Origin of Scientific Thought

Given the challenges involved with using stories in the classroom, are they worth the effort? Focusing specifically on science, many view science and stories as distinct opposites, but is that really the case? Much exploration about the relatedness and connection between the two areas has been done recently and by past thinkers. Poppler (1974) discussed the connection between science and story by suggesting that scientific thought originated in myth. The body of scientific knowledge in existence today is a revised, more sophisticated version of what existed previously. It seems hypocritical to suggest that our current form of science originated in Greek mythology or Nordic legends, but the Greeks and Swedes were simply attempting to explain the world around them using their current understandings and imaginations—much as scientists today attempt to do when explaining disease or volcanic activity, realms of the unknown. The connection between myth and science is almost unbelievable, but the underlying principle is the same. Science *is* a story and its history proves it.

The origin of scientific thought and theory is ultimately rooted in myths and legends—the power of the imagination certainly played a role in early scientific discoveries, spurring on one explorer after another to delve into the realm of the unknown, seeking answers, testing theories, and laying the foundation for further scientific thought. Additionally, when considering how scientific thought elevates to the level of theory, one must look at where the theory began—as an idea, a question about the natural, then a hypothesis, but still far from objective truth. Poppler (1974) with regard to this issue, commented that science is essentially conjecture—scientists, confronted with problems, develop hypotheses or "conjectures," and investigation supports or denies those ideas, leading to the development of knowledge. He further elaborated that the current body of scientific knowledge has developed due to this process.

The word conjecture implies a lack of knowledge or an inadequate basis for thought or belief and many scientific hypotheses are far from mere conjectures, but in essence, many scientific ideas start out as guesses, simple ideas or imaginative thoughts. While a scientific hypothesis may be daunting for students, all students can develop thoughts, ideas or guesses about the world around them—and science education needs to convey that aspect of science. Instead of students being overwhelmed by the "elevated status of scientific knowledge" (Martin & Brouwer, 1991, p. 184), they can be empowered. If students understand that the origin of science and scientific thought lies within myths, stories, and legends, they will also understand that they can play a role in the process. Science becomes something that is no longer unreachable or unfathomable and reserved for the intellectually elite—everyone is capable of making a contribution to science and participating in the adventure.

The Nature of Science

One of the problems with science education discussed in the introduction was that students do not really understand the nature of science after completing science education programs. Project 2061, a component of the American Association for the Advancement of Science (AAAS) outlined some of the key factors necessary in a curriculum to help students develop a more holistic view of science in the publication, *Benchmarks for Science Literacy* (1993). The *Benchmarks* place much emphasis on science as a social endeavor and involving students in realistic investigations, as well as the influence and effects of scientific endeavors on society and the world, which are all foundational aspects of the nature of science.

Many of those aspects are much better conveyed through a story than any other communication medium; they convey that science is much more than knowledge. As Milne (1998) suggested, "narrative structure in school science serves to assist in the construction and transmission of a particular notion of the culture of science" (p. 178).

Stories in the context of case studies and PBL ask students to participate in investigations, to make hypotheses and test them through observation and experimentation. Though often implicitly, the nature of science is perpetuated through such instructional strategies (Roth & Lucas, 1997). While typical school science may focus on the empirical aspects of science, the stories inherent in problem-based activities and case studies challenge students' pragmatic perspectives. Stepien and Gallagher (1993) described that a key benefit of PBL is allowing students to become part of the action—they become doctors, investigators, or environmental activists—and they have a stake in the outcome of the problem. By being so actively involved in the problem, the students also come to realize that the problems faced in the real world are not objective and simple—they involve differing points of view, and complex ways of interpreting information that can significantly affect the outcome (Stepien & Gallagher, 1993). An understanding of the subjectivity of knowledge and its application in the world is significant for developing an accurate perspective of the nature of science, and the stories involved in PBL and case studies bring those aspects of science to the forefront of students' minds.

In addition to subjectivity, mystery is inherent in the nature of science. Often, scientific concepts such as atomic or evolutionary theory are taught in classrooms as "the final word" on those concepts, and while substantial evidence supports those ideas, everything is not fully understood; the element of mystery remains (Hadzigerogiou & Stefanich, 2000). Along with mystery, open-mindedness is another feature of science regularly omitted in science education, but Swartz and Fischer (2001) commented "good scientific thinking requires that we acknowledge the sometimes humbling fact that we could be wrong even in our most basic scientific beliefs, and that evidence might come along that shows this" (p. 305). Stories can serve to perpetuate the mystery of science as well as the transient nature of scientific knowledge.

Martin and Brouwer (1991) stated that the inaccurate view of the nature of science brought about by science education promotes the notion that scientific knowledge is privileged, reserved for the brightest minds alone and it "leads students to imagine that they cannot achieve that level of understanding" (p. 184). Scientific knowledge is inherently difficult to comprehend, but an empirical view of science may further promote feelings of hopelessness; students may believe they cannot understand science because it is naturally so far beyond their abilities. Stories can make scientific knowledge more accessible to students by presenting the struggles of scientists and allowing students to identify with those struggles, as well as seeing that sometimes scientific knowledge develops through chance or error (Milne, 1998).

Solomon, Duveen, and Scot (1992) cited promising evidence that using historical stories helps students develop more adequate views on the nature of science.

They developed a number of historical vignettes, focused on scientists and taught material in that context as opposed to the traditional lecture format. The data collected

> . . . offered substantial evidence that our units for teaching the history of science within the normal school curriculum made a valuable contribution to the pupils' understanding of the nature of science. In particular, there is a significant move away from the serendipitous empiricism and toward an appreciation of the interactive nature of experiment and theory. (p. 418)

These examples provide hope that the situation regarding the nature of science and its portrayal in science education can change and in ways that are not currently being addressed by traditional science education. The cookbook "scientific method" often perpetuated in science classrooms does not tell the whole story of science and many students are left with inadequate or inaccurate views on the nature of science because of such teaching. Stinner, McMillan, Metz, Jilek, and Klassen, 2003 discussed the importance of incorporating the history and philosophy of science (HPS) into the curriculum to avoid such misunderstandings about science. They stated,

> It is necessary to present carefully chosen episodes from the HSP integrally used in the teaching of science, in order to illustrate the creativity, the intellectual struggle involved, the difficulty of communicating with and persuading others, and the necessity of reaching an agreement about definitions, principles, laws and theories. (p. 619)

Where traditional methods have left children with questionable scientific understandings, using historical stories can help to clear up those misunderstandings.

<u>The Human Side of Science</u>

One of the chief factors omitted in science education programs regarding the nature of science is the humanity of the discipline. Often the heart of science is ignored and, instead, it is presented as something outside human influence and relatively unchanging. In fact, many involved with curriculum reform advocate for focusing on the social aspects of science and presenting its discoveries and applications in an exciting way, especially during elementary and secondary education, and waiting until the college years to establish science as a more formal discipline (Stinner, 1995). Stories are a natural vessel for conveying the humanity, excitement, and even weaknesses of science in a way that helps students understand the true essence and nature of science.

The way in which stories convey the humanity of science is inherent—all stories involve characters. And characters possess a variety of qualities that students can connect with; though students may have difficulty finding meaning in the details of science, for example the peculiarities of insects or the inner workings of the cell, stories allow students to see why someone at one point found those topics worthy of investigation. Egan (1997) suggests that by placing such knowledge in the "lives of its makers" (p. 94) and showing why someone found value in the information, such knowledge is more easily accessed and developed within the minds of children. It is through seeing the human desires, hopes, and intentions driving scientists, inventors, and explorers that knowledge becomes meaningful and understood. Egan further elaborates on the topic,

> Instead of seeing math and science, for example, in terms of particular skills, knowledge and manipulations, we would see them as among the greatest of human adventures, full of drama, hopes and disappointments, discoveries and inventions, and of people in whose lives mathematics and science played important roles. By seeing math and science not as disembodied pieces of knowledge or skill, but as the inventions and

> discoveries of particular people, as products of their hopes and disappointments, their struggles and problems, we can begin to re-embed those subjects again in their proper human contexts . . . (p. 64-65)

Students may have difficulty connecting with abstract scientific concepts or seemingly disconnected facts, but they can connect with the human struggles and dreams that underlie the development of scientific knowledge. Scientists are human beings, not intellectually elite aliens, and stories such as case studies present human nature. As Herreid (2003) describes:

> The case study method [reveals] scientists in action, following false leads, stumbling upon correct ideas, having brilliant insights one minute and making stupid errors the next, and serendipity always popping up unexpectedly. (p. 92)

Willingham (2004) suggests that one reason people connect so well with stories and their characters is that the same interpretive processes are involved in understanding the actions and emotions of characters in a story as in real life. Willingham further elaborates, "We evolved as a social species, and so we may have special cognitive apparatus to deal with social situations that are co-opted in thinking about stories" (p. 51). Thus, within a human context, science becomes more easily understood as well as more accurately portrayed.

The Power of Imagination

If the humanity of science is regularly overlooked in science education, then imagination is virtually nonexistent. It is curious that scientists did some of the most imaginative thinking of the past, yet science education is most often completely unimaginative. Consider the most imaginative careers in society today—are they not engineers, designers, architects, scientists, novelists, programmers, artists, and musicians among others? For at least a few of those areas, science clearly underlies the work and processes involved. Heathcote (cited in Butterfield, 2002) described the correlation between science and imagination clearly, commenting, "the big thinkers never separate the information from the inspiration part of their thinking…it is only in schools, where these splits in our thinking occur" (p. 13).

Even when considering novels and works of literature, creations seemingly unrelated to science, have not a few imaginative science fiction novels hinted at a future reality, and in some cases, has not that future become a reality? Consider Mary Shelley's *Frankenstein,* originally written in 1818, or Aldous Huxley's *Brave New World* (1932); in one novel, a human being fashions a life form, and in the other, the quality of life is engineered. Do not both novels, though obviously science fiction, portray events that are eerily familiar to issues faced by the world today? Indisputably, imagination is a key component in science, and stories involve students' imaginations to a level that traditional methods fail to reach.

Not only is imagination crucial to science, but it is also an excellent tool for aiding the learning process. Butterfield (2002) wrote that the best way to learn science and develop long-term understandings is through actively encouraging students to imagine how their new learning connects with prior experiences.

Hadzigerogiou and Stefanich (2000) further discuss the role stories play in involving the imagination of students. They make the point that stories engage students personally and they touch students' lives in ways that other forms of information cannot. Additionally, stories allow students to develop personal meaning; the students are involved with forming understandings using their imaginations, they are not being force-fed knowledge. "The inclusion of narratives as well as strange and unfamiliar situations that invite curiosity, wonder and surprise should be seriously considered" (Hadzigerogiou & Stefanich, 2000, Final Comments section, ¶ 1). If the engagement of the imagination is a requirement for successful science education, than "imaginative narratives" should be regularly incorporated into lessons and units, as opposed to "rationally ordered conceptual structures" (Egan, 1999, p. 52).

Developing Critical Thinking

Developing scientifically literate citizens involves helping students understand the nature of science, but also helping them become critical thinkers. Unfortunately, Beyer (2001) comments, "significant proportions of secondary school and college students cannot effectively carry out the higher-order thinking skills required for success in postsecondary education or in the world of work" (p. 275). Beyer further notes that there is a clear gap between the ability of students to engage in critical thinking and its necessity for real life situations. Stories of all formats can help students develop ways of thinking that model good decision making skills.

Usually, stories are only used in primary classrooms to increase listening skills and vocabulary, but Swartz (2001) suggests using stories to delve into deeper issues and involve critical thinking skills. In PBL or case studies, such deeper issues are explored and critical thinking is naturally evoked. Typically in such learning situations, students are not given all the information; they are given part of a story and asked to find an answer or solve the mystery, a process that involves an array of critical thinking skills (Stepien & Gallagher, 1993). Initially, students are required to identify the real problem (Swartz & Fischer, 2001), and Barell, Hopper, and White (2001) described the ability to identify problems as a crucial life skill. After problem identification, students are forced to seek solutions without a simple answer; they must address a number of questions to find a potential solution, utilizing their creativity, organizing and analyzing their ideas, and further using critical thinking skills to determine which idea or solution is most plausible (Swartz, 2001).

The benefits of using stories to develop critical thinking skills are many. Barell et al. (2001) suggest that the problematic situations which arise through stories challenge and engage the brain, fostering its development and the ability to think productively. Additionally, stories can serve to "engage our minds and bodies in thinking via complex, multifaceted situations where there are no easy, one-word answers" (Barell et al., 2001) which is the kind of thinking required in most real-life situations. Gallagher and Stepien (1995) also stated that learning using problem situations and stories increases long-term retention more than using traditional methods of instruction such as lecture.

The Appropriateness of Stories

Inside and outside of science education, stories play a crucial role in learning. Kim (2003) suggests that "stories are not only the easiest way to produce meaning, but also to understand meaning" (Section II, ¶ 1). Kim also notes that facts are much of what is taught in school and storytelling is perhaps the most effective method for delivering those facts. Especially in science, stories portray that it is more than a "body of knowledge"; it is active and involved.

Stinner et al. (2003) elaborated that well-structured stories are the best way to learn, remember and incorporate new information into patterns of thought and action. A number of researchers have even noticed the curious observation that when given a set of unrelated facts or disconnected material, people will attempt to add details, characters or events to create a coherent context for what they're reading or hearing. Stories are so natural for developing human understanding that inadvertently, people create stories around information they're receiving. Hardy (cited in Egan, 1999) further elaborates on the role narratives play in human experience, commenting, "we dream in narrative, daydream in narrative, remember, anticipate, hope, despair, believe, doubt, plan, revise, criticize, construct, gossip, learn, hate and live by narrative" (p. 52).

Egan (1999) suggests that all people seem to have "sensitivity to the story form…a mental predisposition to organize events, intentions, characters—the stuff of social activity—into particular purpose-driven causal patterns" (p. 163). Egan elaborates

> The story is the crystallization of this predisposition; it is the narrative form that most precisely reflects the predisposition to make sense of the world and of experience in affectively engaging ways. The kind of meaning proper to stories is affective; it engages us by drawing us into the sequence of events. It draws us in by reflecting precisely a pattern by which we seem predisposed to make sense of the world. (p. 163)

Another compelling reason stories are appropriate for the science classroom is that they create a context for learning. Contextless learning is meaningless and leads to rote memorization and a superficial understanding of what has been taught. Stories, in a simple way, invite students into the situation they are describing; they allow students to put themselves into the conflict within the story and imagine they are actually a part of the struggle. As such, the students can find their own meaning in the story.

Disconnection between what is taught in the science classroom and real world relevance is a common problem and stories can help to remedy the issue. Egan (1997) explains that, "any rhythm derives its identity not from the individual elements that make it up but from the sets of relations among them" (p. 60). Stories can reveal connections that otherwise might not be visible or clear to students.

MacIntyre (1981) elaborates on the importance of stories, commenting that narratives help to make sense of events, behaviors, and information. Most people would not care that grasshoppers have six legs and two pairs of wings, but when those features are discussed in terms of survival, obtaining food, and escaping danger, they develop meaning. Martin and Brouwer (1991) went so far as to suggest that placing learning material in context is not simply useful or beneficial; it is essential for developing true understanding.

Egan (1997) also suggests that placing science in a historical context is an effective way to make curriculum "more accessible to students" (p. 222). He elaborates:

> This is not to collapse science to history, but rather to suggest a way of embedding scientific achievements in their historical setting, particularly through discussing the passions, hopes, fears, and intentions of those who developed the scientific knowledge in the first place . . . theories, experiments, and facts become meaningful within narratives of human lives and intentions, one which draws on such transcendent qualities as persistence, ingenuity, patience, accuracy, and so on, in the pursuit of the nature of things. (p. 222)

Stories also effectively engage students in the learning process. They can be used in a way that invites the students to enter in, investigate the topic and, in essence, become a character involved in the plot. Whether the story involves discovering the structure of DNA, finding a cure for Alzheimer's Disease, or reconciling Newton's Laws with Einstein's Theory of Relativity, students, when invited in, become stakeholders in the outcome of the story—they are writing their own roles (Stinner, 1995). Along with playing a role in the story, students play a crucial role in their own learning process. They are required to devise their own lists of questions to solve the mystery, formulate a way to gather information and make that information meaningful—they become actively involved in organizing their learning (Barell et al., 2001). In a science classroom, stories could help students perceive science as not merely a body of facts and concepts, but a journey through uncharted territory—a quest for knowledge and understanding that reflects the true nature of science.

Motivation and engagement are common recurrent themes in lesson planning and curriculum design. It is obvious that if students are motivated about the topic they are studying, they are more likely to understand it, and if they are actively engaged in the material, they are probably actively learning the material as well. Ellis (2001), on the implications of stories on engagement, comments:

> A good story involves the listener in many of the strategies of gathering the facts of the story, making predictions about the outcome, and checking their hypotheses against the unfolding details of the tale. Also, you can use a story to make abstract concepts personal and tangible. Important facts can be conveyed within a dynamic context so the facts stick; they have more meaning and impact. (¶ 5)

Ellis (2001) also stated that teachers naturally know the importance of using a story in the classroom because of its engaging qualities. While a classroom may be relatively quiet when a teacher is lecturing and students seem to be paying attention, the level of engagement is entirely different; as a story is being told, people innately put themselves into the story. Partially, stories are engaging because they make seemingly impersonal material very personal. Butterfield (2002) describes that many teachers are changing their approach in the classroom because of the personal connections invoked by stories.

> The importance of readers experiencing or "living through" a work of literature is upheld by constructivists in educational psychology and by holistic teachers to be essential to the process of meaning making. This theory rests on the belief that true understanding only comes as a result of making connections and finding parallels between the work of literature and the life of the reader. (p. 5)

Additionally, stories are much more engaging than the current literature medium of choice in science education, textbooks. How many people would choose to read Physics 101 over a story about air travel or the invention of electricity? According to Hadzigerogiou and Stefanich (2000), "The story can at times communicate in a few words that which a dense, technical analysis might require many lines to accomplish" (The Use of Storytelling section, ¶ 15). Willingham (2004) bluntly describes stories as being much more engaging and the obvious preferred choice over textbooks, regardless of the topic. As opposed to expository text, which is often an inventory of facts and concepts, the structure of a story inherently leads the listener (or reader) to "make inferences that are neither terribly easy, nor impossibly difficult. New information that is a little bit puzzling, but which we can understand, is deemed more interesting than new information that is either very easy or very difficult to understand" (p. 44).

Stories have another distinct advantage over textbooks in that they mirror real-life. Narratives about complex topics can seem more apparent and less abstract for students than other forms of information. Although the "privileged status" of a story is not well understood (Willingham, 2004), real-life processes are involved in understanding a story. Conversely, the tools used to understand textbook material are not commonly used when dealing with the real world. Reading information simply for the sake of learning facts and memorizing steps is not a skill readily used in the workplace or within social networks—they are skills with limited use. Seeking to understand the individuals involved in a person's daily life is a task that all people undertake, and stories extend that process to a level outside of the individual to the world at large.

It is inherent that stories are engaging and captivating. Whether in the form of a movie, Harry Potter or science fiction, stories capture the interest of those involved much more than other forms of information (Willingham, 2004). Stories require the mind of the listener to become involved and take part—a person watching a movie or reading a book, while not directly involved in the plot, still wonders how the movie or book will end and in a sense is playing an active role.

Unfortunately, tapping into the engaging qualities of stories has proven to be challenging. Egan (1997) elaborates, "narratives . . . can provide a powerfully engaging access to knowledge of all kinds . . . but there has been relatively little ingenuity expended on working out how to turn its obvious engaging power into practical educational advantage" (p. 59).

If stories are motivational and engaging, then it follows that they would also be easier to remember and comprehend than other forms of literature or information. Probably most people can attest to the fact that remembering the details of a story is much easier than remembering expository text or an instruction manual. According to Graesser et al. (1994), it is the structure of a story that renders them easier to remember and comprehend. The layout of a story is familiar to most people and therefore, people generally know what to expect to a certain extent—in other words, people have a mental representation of a story's structure, thus they are easier to remember because the mind is not lost in the format and arrangement of the information (Willingham, 2004).

Bartlett (1932), in a series of studies on remembering, concludes that the mind recognizes that incidents occur because something caused them and seeks to make connections between the various elements of a story during the sense-making process. In a particular study, he had participants read a mysterious folk story filled with many seemingly disconnected and irrelevant events. His results from the study indicate that when participants were asked to recall the stories, they added details and changed the text so as to make it more coherent. Key points remained, irrelevant facts were omitted, and details were added as participants struggled to understand the material. While adding information may seem dangerous and misleading for students in the classroom, stories allow for students to be engaged in making sense of what they are learning. Their minds are engaged in actively constructing knowledge and connecting it to prior experiences and learning.

The Influence of Culture

Stories also have strong connections to culture. Milne (1998), on the ties of stories to culture, stated, "Narrative is a feature of all cultures and it is used in a culture as a mechanism for promoting learning" (p. 176). White (1981) comments that cultures utilize stories as a way to "[endow] experience with meaning," but stories are also transcultural in that, "narrative is a metacode, a human universal on the basis of which transcultural messages about the nature of a shared reality can be transmitted" (p. 1). Milne (1998) further notes "stories are an undeniable feature of the human condition" (p. 176) and Egan (1999), regarding the connection between culture and stories, elaborates:

> The story has been one of the main media for initiating children into the adult world of knowledge and understanding in most places and times. Through myth and story-shaped ritual, or myth and ritual intertwined, the young have been inducted into full membership of their culture. Clearly our educational needs are significantly different from those of myth-using cultures, but the near universality of the story form as the conveyor of the most important truths about the world and experience should provide at least a superficial tug on our attention. (p. 162)

Stories are indeed part of the human condition as many times when a person speaks to someone, he or she is telling a story. Whether the discussion revolves around the workday or last night's social event, people discuss in terms of cause and effect relationships—key elements of a story.

<u>The Affective Domain</u>

A clear difference between stories and traditional methods of teaching is that stories evoke the emotions. Good stories involve the listener or reader not only at the cognitive level, but also at the emotional level. Typically, though, emotions are left out of teaching, especially in science education, as Dlugos (2003) comments:

> In science there has been a long-standing, Newtonian-Cartesian tradition of separation, prizing apart the mind and body, divorcing and polarizing reason from feeling. From Francis Bacon to Richard Feynman, emotion has been viewed in Western philosophy as a hindrance, a countenance to reason, truth and objectivity. (p. 614)

Dlugos (2003) elaborates that cognition and emotion are usually viewed in opposition to one another and attitudes and beliefs usually result from one or the other, but that "the affective and cognitive seem inextricably intertwined: feelings are typically based on thoughts and judgments" (p. 614). Laukenmann, Bleicher, Fub, Glaser-Zikuda, Mayoring, and von Rhöneck (2003) stated that specifically focusing on cognition neglects substantial elements of learning and powerful tools for making learning meaningful.

Egan (1989) comments that the emotions are usually viewed as only appropriate for the arts, or the "educational margin or frills" (p. 29), but he notes:

> We make sense of the world and experience "affectively" no less than "cognitively." We are not divided into two distinct parts…the dominant model and its associated research programs have tended to suppress the affective aspects of learning. Consequently, they have drawn on only a divided part of children's capacities. (p. 29).

Egan (1989) further notes that stories appeal to children's learning capacities to a greater extent than other, purely cognitive teaching strategies, and their utility is worth serious consideration. In addition, combining cognition and emotion more adequately develops critical thinking skills, as decisions usually involve a combination of two domains (Dlugos, 2003).

Regarding science education, Alsop and Watts (2003) remark that much more than cognition is involved in learning processes. They elaborate that emotions can have negative aspects, in that floods of emotions can make learning virtually impossible, but they also can serve to ignite feelings of enthusiasm and excitement, which are powerful motivators for learning. Laukenmann et al. (2003) stated: "Various experimental studies have shown that a positive mood reinforces creative and fluid thought processes, an effect that is explained via information processing theories" (p. 490). Egan (1997) further suggests that using an affective means to initially establish meaning may be the most effective method for later developing a more detailed cognitive level of understanding.

The study of science is also closely connected with emotions. Henri Poincare` (cited in Martin & Brouwer, 1991) comments, "The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful . . ." (p. 709). Passion and beauty often motivate scientists and only through being passionately affected, can a scientist develop deep understandings of his or her observations or experiments (Laukenmann et al., 2003). Wagenschein (cited in Laukenmann et al., 2003) further describes that "there is no significant scientific discovery that is unaccompanied by emotions" (p. 490). Additionally, emotions attribute value to a scientist's observation and methods as well as spur him or her on to a higher quality of study (Martin & Brouwer, 1991).

Martin and Brouwer (1991) also note that the emotions evoked by stories can also serve to put science in a proper context. Bruner (1990) suggests that typically there are two modes of thought involved in education: The paradigmatic mode which emphasizes traditional aspects of science education, involving concrete facts and empiricism, and the narrative mode which incorporates the use of literary devices to explain scientific ideas, as well as develop meaning. Typically, the paradigmatic mode is what is employed in the science classroom.

> But it cannot be the sole mode of thought employed. If we are to address seriously the problem of having students acquire a more authentic understanding of science in all its diversity, then the narrative mode should become part of the intellectual approach used by science students and teachers. (Martin & Brouwer, 1991, p. 711)

They elaborate on the affects of aesthetics on science education, and suggest that:

> A sense of the aesthetic would entail a sense of fullness and coherence, which places ultimately the science learned in school within the broader weave of the curriculum and ultimately the student's life beyond the walls of the school. In practical terms, we require a pedagogy that strives for such an aesthetic within science education...The narrative mode strives toward verisimilitude, the creation of a plausible world of shared experience between the writer and the reader. (p. 711)

Emotions connect meaning with knowledge to create powerful learning experiences. Most people can attest that facts and experiences are much easier to remember if they are tied to emotions, and education can benefit from making such connections. Even science as a discipline is "inextricably intertwined" with aesthetics and emotions. Though the emotional realm of science has been mostly ignored, it seems worthy of further investigation.

Chapter III

ACTION RESEARCH

<u>Purpose</u>

The types of stories and potential effects of their use on learning in the classroom are extremely varied and complex, so researching their effectiveness is a challenging task. For this action research, I chose to focus on one type of story, news stories, which I adapted to make them shorter and easier to read. News stories are very informational and they are formatted in a way that quickly and succinctly conveys the main ideas of the story. In addition, they are readily available in abundance, so preparation time was minimized. Throughout the research project, I investigated two learning outcomes, motivation and critical thinking. Although it would have been interesting to investigate the nature of science or the involvement of the imagination, those outcomes seemed beyond the scope of this particular research project. I chose to study motivation because it has been positively supported by previous research and I wanted to confirm those results in my own classroom. I also chose to investigate critical thinking because I have noticed a lack of such thinking skills in my own classroom and want to develop those skills in my students.

My research focused on the following question, "Does presenting information in a story format motivate students and encourage critical thinking more than using a lecture format?" I hypothesized that both learning outcomes, motivation. and critical thinking, would be positively affected by the use of stories as opposed to using a lecture to convey information.

Background Information

Three sections of 10th-grade Fundamental Biology were involved with this research project during the spring trimester. Biology is a graduation requirement, so all students must take it and Fundamental Biology is an adapted biology course for students who received a D or F grade for at least two trimesters in ninth-grade physical science. A total of 58 students were observed over the course of the research; 40 students were male and 18 were female. Additionally, 30 students were receiving special education services and two were involved with the English as a Second Language program. All of the students involved in the research had been in my classroom the entire school year as I am the only teacher who teaches the Fundamental Biology course.

The sections were observed over a period of approximately 5 weeks, as the classes progressed through the last two units of the school year, the first unit entitled, "Marine Biology" and the second, "Life on Land." Both units were organized around the theme "survival and destruction" but involved significantly different methods to convey information and develop learning.

Method

During the Marine Biology unit, students were taught using traditional methods to establish a baseline. The lessons typically began by having students respond to opening thought questions in their journals. The questions usually relate to prior learning or personal experiences connected to the material they are going to learn during the lesson. After opening questions, students share responses with a large group followed by a short lecture of about 10-15 minutes. During lecture time, I encourage active participation by asking students questions about the material, and connecting the lecture to their journal responses. Students are free to respond at will most of the time, except when some students seem to dominate the discussion, and then I intervene and call on students. The last 15-20 minutes of class are used to work on assignments and projects.

I recorded observations for five lessons during the Marine Biology unit. Approximately every other lesson was observed; alternative days did not involve a lecture or discussion. To assess motivation during the baseline, I recorded student participation during the large group discussion and lecture. A simple tally sheet was used for each section and I attempted to record as much as I could during the discussion and lecture, but I also had to go back at the conclusion of the lecture and the supplement my notes. To assess critical thinking, I recorded student responses to my questions and made note of significant contributions in my field notes after the discussion and lecture were complete. Critical thinking is more difficult to assess, but I attempted to make note of when students asked additional questions and the level of their responses; i.e., were their responses shallow and did them seem to have a superficial grasp of the material or were they deeper, involving previous knowledge, personal experiences, and involving material we had not discussed in class?

My intervention during the Life on Land unit involved reading news stories as the opening activity and having students respond to thought questions directly related to the news stories. The stories used can be found in Appendix A. The thought questions were then discussed as a large group and a lecture/large group discussion directly connected to the news story replaced the traditional lecture utilized previously. Essentially, through their discussions, the class formatted their own notes with my guidance and direction and I added supplemental information as the lecture progressed. Four lessons were observed during the intervention period. As before, the remainder of the class period was spent on assignments and projects.

<u>Results</u>

The data for total responses/participation is shown in Figure 1. Data collection during the baseline period (Days 1-4) indicate a relatively stable number of responses. The average rate of participation for the baseline period was 58 responses per day. During the intervention period, with the exception of the first day of the intervention (Day 5), there also seems to be a trend toward a stable number of responses. The average number of responses during that period of observation was 65.25 responses per day. The average number of responses for the last 3 days of observation (Day 6-8) was 72.67. Figure 2 shows the number of responses per class section.

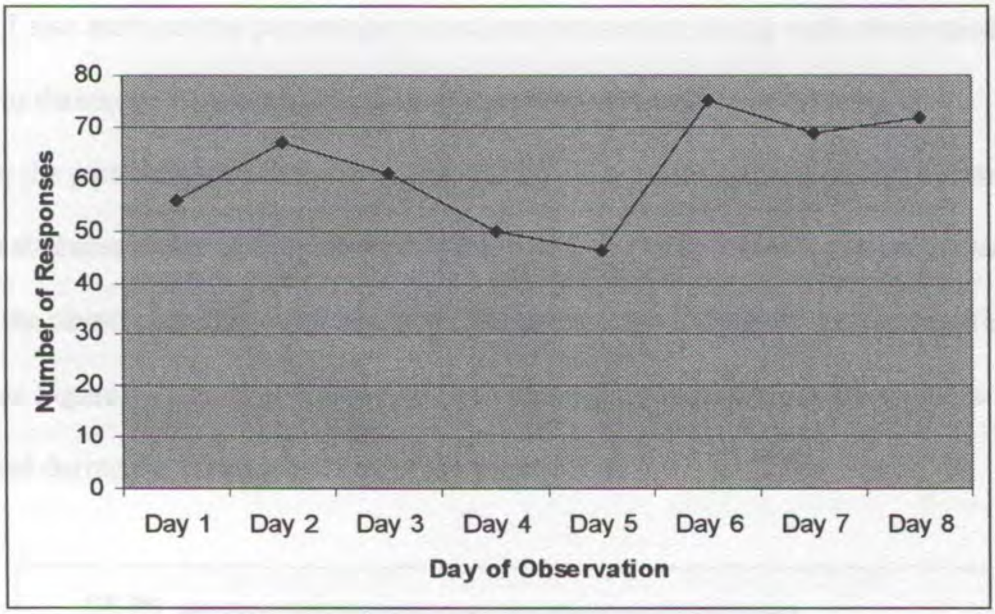

Figure 1

Total Responses

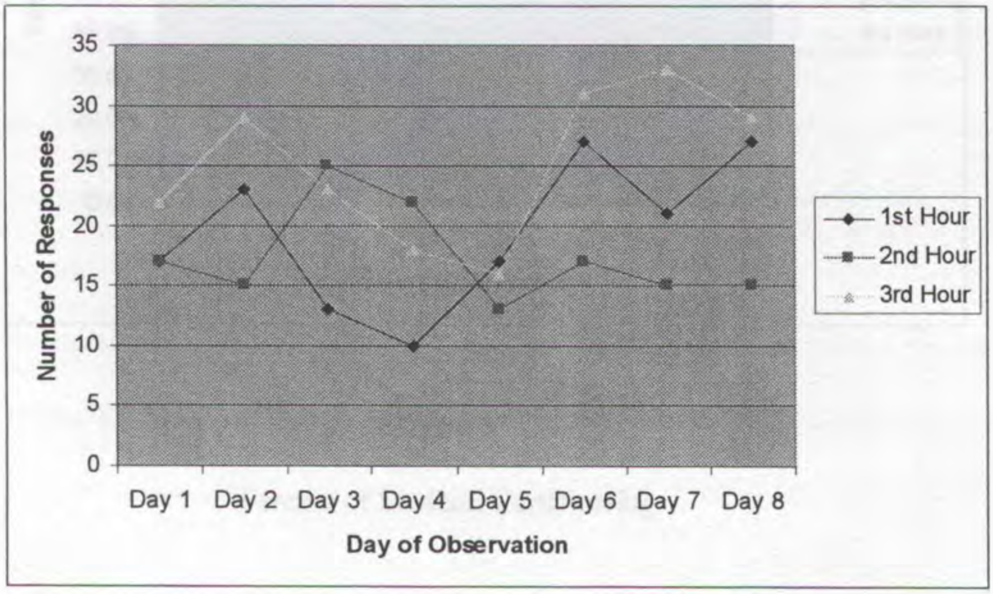

Figure 2

Responses by Class Section

I also analyzed the percentage of students responding during each observation period to determine whether it was the same students constantly contributing or whether the participation was more evenly spread. This number also took into account student absences as the participation percentage included only students present in class during the observation day. The results for the percentage of students responding are shown in Figure 3. This figure is divided into separate class sections as they will be discussed during the analysis portion of the paper.

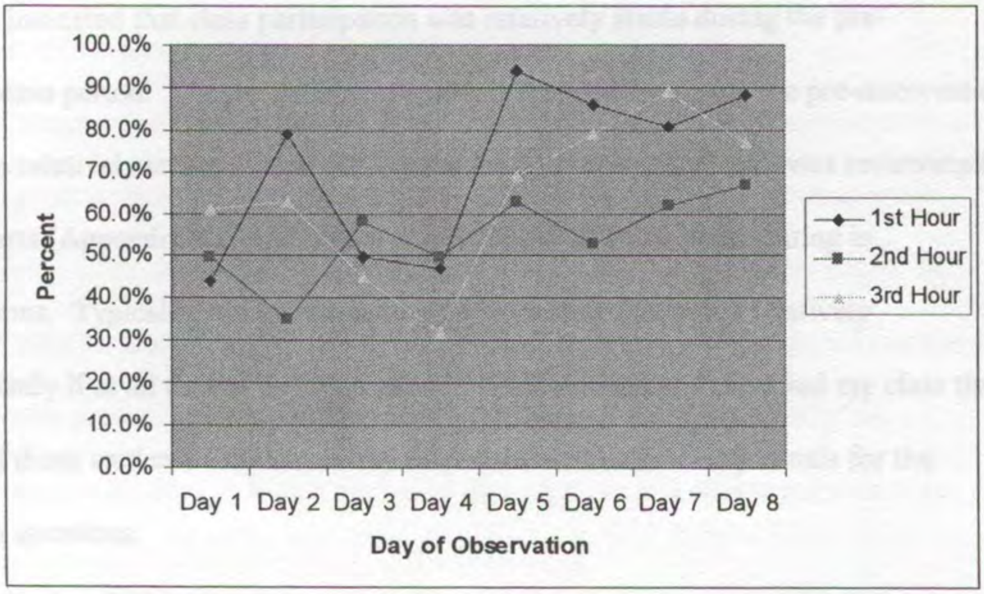

Figure 3

Percent of Students Participating

DATA ANALYSIS AND DISCUSSION

Motivation

The component of motivation was assessed by the participation rate of the students. I determined that if students were motivated about a topic or activity, they would be more active in the classroom and participate more frequently. Especially since I have had these students all year and they know my style of teaching and are fairly comfortable in my classroom, I felt this would be an adequate measure. Overall, the data indicated that class participation was relatively stable during the pre-intervention period. The percentage of students responding during the pre-intervention was also relatively stable around 50% of students participating. As I was reviewing the data charts (Appendix B), I did notice a trend in the students participating in discussions. Typically, the lowest achieving students participated relatively infrequently if at all during the class period. I also noticed as I observed my class that some of those students didn't have any responses written in their journals for the opening questions.

During the intervention period, the rate of participation seemed to increase, as did the number of responses, and I contend that the stories were more interesting and engaging for the students, thus they responded more. The same trend was noted with the low achieving students as during the baseline period, though. It seemed that incorporating stories into the curriculum did not affect their participation. Involving more of those students into my discussions has been a challenge all year, and some do not participate regardless of the learning activity.

An interesting observation was that the percentage of students responding during the intervention period increased overall for the first- and third-hour classes, but second hour was the exception. The rate of participation remained relatively unchanged for that section throughout the research project. This section contains 60% special education students and those students are some of the more low achieving students in the special education program. In fact, many of the students in that class period are assigned to that particular section by their special education case manager. It is obvious that more investigation needs to be done and other adaptations attempted to involve those students more in learning activities.

Though slight trends were indicated for number of responses and percentage of students participating, a longer investigation period is necessary to develop more conclusive results. Additionally, because the differences noted were so minor, they may not indicate statistically valid results. It cannot conclusively be stated that the data indicate that stories increased the motivation of the students by analyzing the participation data only. A longer period of investigation of 2 to 3 months or more would offer better, more substantial, and valid results.

It was curious to note that Day 5 had the lowest overall number of responses. Day 5 involved the story about the deformed frogs and it was also the first day of the intervention. I believe the novelty of the activity was challenging for some of the students. Many students seem to thrive with constant structure; they perform best when the same activities are repeated regularly without diversion. Change for some students is challenging. I think that initially, students were challenged by the new activity and did not know what I expected of them, so they participated less. All three classes had substantially lower rates of participation. Additionally, this observation day was on a Friday immediately after the classes had taken a day long field trip, so the students seemed more tired than usual.

Critical Thinking Analysis and Discussion

The critical thinking aspect of this research project involved the assessment of the students' contributions in class, according to their depth, incorporation of previous knowledge and adequate substantiation of their responses. Though there are more valid assessments of critical thinking available, such tests were beyond the scope of this particular research project and I recorded my impressions of critical thinking in my field notes (Appendix C).

During the baseline period, I was not surprised to discover that it seemed there was little or no critical thinking involved in my classroom discussions. Only the highest achieving students seemed to put much thought and effort into their journal entries for the opening questions. Additionally, the student participation during lectures was minimal. Most of the questions asked were not beyond the knowledge or comprehension level of understanding. It was apparent that students were not utilizing critical thinking and that the opening questions and lectures were not affording them the opportunity to utilize such skills.

During the intervention period, however, I noticed several differences from the baseline period. First of all, it seemed that the majority of students were responding to the questions in their journals and honestly thinking about what was being asked.

Additionally, more time was needed during the discussion for students to formulate their ideas and more probing was necessary as well. I felt it was easier for me to challenge my students and draw their minds into deeper levels of understandings through the stories and accompanying questions and discussion period than during the traditional classroom sessions.

Basically, the format and content of the discussion questions allowed for deeper thought and analysis. Critical thinking skills were naturally incorporated into the questions that arose from the stories. The stories allowed students to analyze data, formulate ideas, and devise possible solutions, and they also were required to support their responses with evidence given in the stories. Although critical thinking can certainly be involved using traditional teaching methods, I think it is much harder to incorporate such skills.

Discussion and Analysis on Other Observations

A more obvious change during the intervention period was that the students seemed more excited to participate in the discussions. During the baseline period, many students seemed reluctant to participate, probably due to the fact that many of the questions asked involved rote memory, or they simply did not deem the activity worthy of participation. However, during the stories, particularly the story about the "River Dino," many students seemed eager to participate. Additionally, students seemed much more focused during those discussions during other times. Behavior problems also seemed reduced.

An encouraging observation was that the students seemed also to be using their imaginations. During the "River Dino" story, one student drew a picture of what he thought the reptile would look like in real life. The quality of the responses also indicated imagination and deep thinking. During the amphibian discussion, students responded with all sorts of possible causes for the deformities, from evolution to genetic changes to global warming. They utilized previous knowledge and imagined ways that knowledge could be valid in that situation.

Additionally, though I was not investigating the nature of science, it was apparent that aspects of the nature of science were naturally revealed through the stories. Students were shown that science is a quest for the unknown as three of the stories involved mysteries. They were also shown that science is more than knowledge; it involves seeking answers to relevant problems facing the world today. The Avian flu case and the deformed frogs both directly or indirectly relate to the health of the planet and the human race, so students were shown that science is concerned with solving real problems. Whether or not the stories actually had a long-term influence on student perceptions of the nature of science was not studied, but the stories certainly presented science in a more realistic way.

Chapter IV

CONCLUSION

Throughout this paper I have investigated the ways that stories can be used in the science classroom, their potential effects as well as challenges to using them. Additionally, I researched the effect stories had in my own science classroom. Some of the challenges with using stories described during the literature review were reluctant students and the time-intensiveness, and I can attest that such challenges are definitely valid, but the possible learning outcomes of using stories far outweigh any negative aspects.

The variety of ways stories can be used from news stories and poetry to case studies and problem-based learning, make them very versatile learning tools. Stories can be adapted for almost any learning situation and topic and although some topics may require the development of original materials, the effort will be much rewarded in the classroom as was shown by my action research. Simply seeing students more engaged and interested in science encouraged me to utilize stories more in my curriculum. My action research also only focused on a single type of story (news stories) and two outcomes (motivation and critical thinking), so the effects could be greatly multiplied through the use of other kinds of stories in the science classroom.

What science teacher would not want his or her students to be excited about science or to understand the nature of science more adequately? To develop the critical thinking skills necessary to be a scientifically literate individual? To use their imaginations? As indicated in the literature review, stories open up the possibilities for all these things in a way that traditional methods seem to fail.

The implications for future research regarding stories and the science classroom are vast and complex. Although I would have liked to investigate the nature of science through my action research project, that particular outcome is difficult to assess and would involve a very long-term, intensive project. Some nature of science questionnaires are in existence which have been utilized in other research projects, so investigating that aspect would be feasible and certainly recommended for anyone pursuing an interest in stories.

My assessment of critical thinking was based solely on my observations and personal evaluation of critical thinking involved in student responses, but more substantial assessments of critical thinking would be of benefit as well. Materials for such studies have been developed and used in previous research, so the assessment of such skills would be possible, but this would probably also be a long-term project. Given the importance of critical thinking skills within the work place and social circles, it should be a crucial factor in education and the effect of stories on such skills is also worthy of additional research.

The effect of stories on comprehension, understanding and the involvement of the imagination is also a topic that would also be interesting and necessary to investigate. With the current system of standards based learning and standardized tests, increasing comprehension is a major factor with any curricular reform. So many of the factors involved with the utilization of stories are so abstract and complex that assessing them would be challenging, but more research is necessary to substantiate any claims stories may have on their influence and efficacy.

It is apparent that science education must change. First of all, students are leaving schools with poor understandings of science and surface knowledge. More importantly, though, students are missing out on an opportunity to be enthralled by the world around them. An inaccurate portrayal of the nature of science can turn students away from the most wonderful aspects of all creation. Even the most glorious, beautifully constructed building or work of art does not compare to the mountains, waterfalls and skies of the natural world. When one considers that buildings and works of art are based on the physical and chemical properties of the matter composing those structures, it is apparent that science is everywhere. The most genetically engineered animal or programmed robot still does not even come close to having the complexity of the human brain and body.

There is much more to science than what is commonly taught in the science classroom, and students' minds, imaginations and hearts are being left behind. Stories, while a novel or seemingly risky concept, provide hope that science education can change. They provide the encouraging thought that students can learn difficult scientific concepts and vocabulary while developing critical thinking and a deep understanding of the nature of science at the same time as their hearts are being captured by the mystery and magic of the natural world.

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APPENDICES

APPENDIX A

Stories

Avian Flu Story

INDEPTH: AVIAN FLU
The next pandemic?
CBC News Online | March 8, 2005

H5N1. A string of numbers and letters that has the World Health Organization deeply concerned.

It is one of 15 varieties of avian influenza – bird flu. So far, it is the only one that's shown any ability to directly infect humans. Twice.

Hong Kong, 1997. Eighteen people are stricken with severe respiratory disease. Six of them die. The cause – the H5N1 strain of avian influenza. The infection of humans coincides with an epidemic of a particularly nasty bout of avian influenza in Hong Kong's poultry population, caused by the same strain.

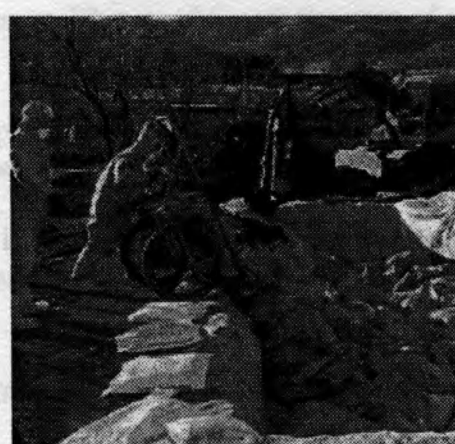
Health officials determine that close contact with live infected poultry was the source of human infection. It is the first time that evidence can be found that the virus had jumped directly from birds to humans.

Health officials order the destruction of Hong Kong's poultry population. More than 1.5 million birds are killed in three days. There are no more cases of direct transmission of the disease from birds to humans. Some health experts say the action may have averted a pandemic.

Vietnam, 2004. Eight new cases of avian influenza in people. Six people die. Health officials order the culling of millions of birds to try to minimize the threat to people.

But killing millions of birds has not eliminated the threat to people from avian flu. By Feb. 2, 2005, 55 people in Vietnam, Cambodia and Thailand had come down with the disease – 42 died.

That's an extremely high percentage – one that has the WHO warning countries around the world to get ready in case bird flu is the next big one.



South Korean officials dump bags of chickens in Yangsan. (AP photo)

The WHO says influenza pandemics can be expected to occur three or four times each century, when new virus subtypes emerge and are readily transmitted from person to person. The last great pandemic occurred in 1918-19, when Spanish flu swept the world, killing 40-50 million people, including more than 50,000 in Canada.

Experts agree that another pandemic is inevitable and possibly imminent.

The WHO is paying particular attention to H5N1 for several reasons:

- It mutates rapidly and now has a history of being able to acquire genes from viruses infecting other animal species.
- It has caused severe disease in humans.
- Laboratory studies have demonstrated that isolates from this virus have a high pathogenicity and can cause severe disease in humans.
- Birds that survive infection excrete virus for at least 10 days making it easier to spread the virus at live poultry markets and by migratory birds.

The WHO also says the epidemic in birds caused by H5N1, which started in December 2003 in Korea, has spread to other countries. More infected birds increases the opportunities for direct infection of humans. If more humans become infected, the WHO says the odds also increase that humans – if they're infected with human and avian influenza strains at the same time – could serve as a "mixing vessel" for a mutated virus that spreads easily from person to person. That would mark the start of a flu pandemic.

Alberta's health minister—Iris Evans—says most people do not understand how overwhelmed the health-care system would become if there were a flu pandemic.

"What worries me most is the ignorance of people in the public who assume that if they get sick there'll be something there for them, and they do not realize the devastation this could be."

Flu would hit health-care workers as well. As many as a third of Canadians could fall ill at the same time.

Virologist Dr. Todd Hatchette is concerned about H5N1.
"The virus has gained the ability to infect a large number of hosts . . . not only the chickens that it normally infects but tigers, cats and transmitted to humans, and there's some evidence that it is refining its genes, if you will. I'll suggest that it is pretty good evidence that this will probably be the next one."

In February 2004, another strain of avian influenza—H7N3—swept through B.C.'s poultry industry. The province ordered more than 17 million birds killed. It took about six months for the province to be declared free of avian flu. While the outbreak was devastating to poultry farmers, no people got sick.

The former medical officer of health for Ontario—Dr. Richard Schabas—is not convinced that H5N1 is a pandemic-in-waiting. "Our science just is not strong enough for us to know that and it is not strong enough for us to be making these kinds of alarmist predictions that we're hearing from the WHO and others," Schabas told CBC News. "This is the third time the WHO has told us were on the brink of an avian influenza pandemic. They said it in 1997 and they were wrong. They said it a year ago and they were wrong."

Retrieved from: http://www.cbc.ca/news/background/avianflu/index.html on May 22, 2005

Beached Dolphin Story
Marine Mammal Mystery

Investigators are trying to find out if a US Navy submarine's sonar caused a pod of dolphins to swim into shallow water near a beach in Florida last week. More than 20 of the roughly 70 rough-tooth dolphins died as a result.

The sub, The USS Philadelphia, was conducting exercises off the shore of Florida the day before the dolphins became lost and beached themselves. The Navy will not say if the sub was using sonar as part of its top-secret activities, but it is working with marine wildlife experts on the investigation. Sonar is the use of loud sound waves to detect the presence of objects in the water useful to submarines for identifying enemies approaching.

Sonar can scare and disorient marine mammals and also damage their ears. It had led to the beaching of dolphins and whales in the past. But that is not the only possible reason these dolphins got lost and so far it is a mystery.

One biologist working to figure out what happened is Laura Engleby of the National Oceanic and Atmospheric Administration Fisheries Service. "This kind of mass stranding is very perplexing," but not unusual, especially off the coast of Florida, she said. "We take as many samples from the dolphins as we can in order to get clues and then we piece together the clues. Each time there is a mass stranding we learn a little more. We're trying to find patterns."

Engleby said the submarine's sonar is just one possible explanation she is looking into. Other possibilities include a virus, disease, or naturally occurring toxin, such as the "red tide" that caused the death of 107 beached dolphins last summer, also in Florida.

"It is never easy when you see a mass stranding of this number of dolphins. At the same time, it does give us an opportunity to learn a lot about the species and hopefully help them in the future," she said.

In the meantime, Engleby is also working with a group of volunteers to care for the surviving dolphins. "It is kind of like a hospital ICU unit, where they have a chance to rest and get re-hydrated and recover."

When they are well, the dolphins will be released back into the deep waters where they belong.

Retrieved from
http://www.nick.com/all_nick/tv_supersites/nick_news/stories_weekly.jhtml?pollId=315009140&wstory=0 on May 15, 2005

River Dino Story

Mystery reptile loose in county?
July 30, 2002
By Katharhynn Heidelberg
Journal Staff Writer

Could the Southwest be home to a mysterious new species of reptile?

Nick Sucik, a private researcher from Minnesota, thinks it is possible. Sucik has been tracking sightings of an elusive lizard-like creature ever since hearing tales of "river dinosaurs" from those involved in the legally sketchy "reptile trade."

The "dino" is said to walk exclusively on its hind legs; to stand about 3 feet tall; and to have armlike appendages instead of forelegs. The reptile usually is seen near a wet environment and moves swiftly, with grace, Sucik said.

Reports of sightings trickled in, first in Pagosa Springs in 1982, then in Pueblo, Sucik said.

And, he said, the same thing happened here in Cortez—"But it was kind of unexpected how we heard about it."

An *Unsolved Mysteries* episode had featured the story of a Cortez couple who had been visiting in Arizona. While there, the couple apparently saw the body of a reptile unlike any they had ever seen before. "It looked like a toy to them," Sucik said, and when they told their tale, "No one took them seriously."

Except, perhaps, for Sucik himself.

In an attempt to follow up on the story, Sucik wrote the *Journal* and later placed a classified ad, seeking communication from anyone who might have seen the enigmatic reptile. The letter netted a response from Northern California, but the ad brought results from closer to home.

According to Sucik, a woman and her daughter e-mailed him details of a similar sighting that took place in 2001 as they were driving in the Yellow Jacket area.

"Suddenly, this thing runs out. At first, they thought it was a young deer, because of its size," Sucik said.

The women described it as having a long neck and skinny legs like a bird. However, it had no feathers and its "arms" seemed to go out of its upright neck rather than its body.

The women estimated that the creature would measure about 5 feet, if stretched from neck to tail.

"It looked to them like a cross between a bird and a dinosaur." When they got home, each drew a picture of the creature and realized they had each seen exactly the same thing," he said.

The description matched that of other sightings, and the women happened to have been near an irrigation creek. "Every reference we've heard usually affiliates them with water," Sucik said. "That's where the term 'River Dino' comes from."

Sucik discovered it wasn't the first sighting in the area. In March or April 1996, a local woman said she saw something similar near her home at the Kampark outside Mesa Verde.

"I was sitting on the couch, and looked out the front door," the woman, who did not wish to be identified, told the *Journal*. "I saw something, not a lizard, really, about 3 1/2 feet long and 3 1/2 feet high. It moved very fast. As far as I remember, there were only two legs that seemed to balance it."

She said the creature moved very swiftly, and had a cone-shaped nose and a tail that extended about 2 feet out from its body. It had come from a pond area.

"It was kind of unusual," she said "I didn't know if I was seeing things, or what. I never had anything like that happen before.

"I thought, 'Maybe it is someone's pet', I wasn't frightened; I just thought it was unusual."

She checked reference books, but could not find anything similar to what she'd seen. Jeff Thulin of the Reptile Reserve told her it might have been a monitor lizard, however, monitors could not live throughout the winter locally.

Thulin said others have since mentioned that they have seen "a large lizard running around. I do not know any specifics at all except that it is large and looks out of place."

"It does not match anything," he said of the description.

The woman said she has tried to put it out of her mind. "Some people think you're nuts."

Sucik is not sure what people have seen. A lizard, he said, "is a reptile on four legs. These reptiles are always on their hind legs. The only reptile to fit that morphology is a dinosaur — that kind of creates extra interest."

"It is not strange. It is like a new species that hasn't been classified in the area."

Sucik said it is possible the reptile is an escapee from trade in exotic pets. Even so, the description does not match anything known, he said.

Retrieved from http://www.abovetopsecret.com/forum/thread918/pg1 on May 15, 2005

Deformed Frogs Story

Deformed Frogs in Minnesota
Where did this problem start?

In August of 1995, students from the New Country School in LeSueur, Minnesota found large numbers of deformed frogs in a wetland they were studying near Henderson, Minnesota. They found many frogs with deformed, missing or extra legs, as well as deformed eyes or other parts.

Before the end of that season, similar frogs had turned up elsewhere in the Minnesota River Valley. Minnesota's deformed frogs became big news. Researchers agreed they'd never seen anything like this. Everyone wondered what could be causing these unusual defects, and scientists started investigating.

But then it got worse. In the summer of 1996, deformed frogs were reported all over the state. By the end of the year, the MPCA had gotten more than 175 reports of deformed frogs, in two-thirds of Minnesota's counties. Late that summer, we began hearing that deformed frogs were being found in other states as well, even in other countries.

Why are we concerned about the deformed frogs?

Frog populations around the world have showed increasing signs of stress in recent years. Some species have disappeared, and others are no longer found where they used to be. An increase in deformities may be a sign that something is wrong.

Scientists are concerned about what's happening to the frogs, because the health of frogs is closely linked to the health of the environment. Frogs are sensitive to pollution, because they live at the meeting of two environments—land and water—and they can easily absorb pollutants through their skin.

Just as miners used canaries in the mines to alert them to poisonous gases, frogs may alert us to problems in our environment.

Retrieved from http://www.pca.state.mn.us/hot/frogs.html on May 15, 2005

APPENDIX B

Data Tables

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
1st Hour	**Partic.**	**Partic.**	**Partic.**	**Partic.**	**Partic.**	**Partic.**	**Partic.**	**Partic.**
Student 1*	4	1	2	2	1	2	1	2
Student 2*	0	0	0	0	0	0	0	1
Student 3	0	a	0	a	a	0	0	0
Student 4	0	0	0	0	a	1	0	1
Student 5*	0	1	0	0	1	a	1	1
Student 6*	a	2	1	1	a	3	2	3
Student 7*	1	2	0	0	1	2	1	0
Student 8*	0	0	a	1	2	2	3	2
Student 9	1	a	0	0	1	a	2	1
Student 10	3	a	2	1	1	2	1	2
Student 11*	0	3	1	0	2	3	2	3
Student 12	2	4	3	0	2	3	1	3
Student 13*	0	2	1	0	1	1	1	2
Student 14*	1	1	2	a	1	2	3	2
Student 15*	2	2	1	3	2	3	2	1
Student 16*	2	3	0	1	1	3	1	2
Student 17*	1	1	0	1	1	a	a	1
Totals	**17**	**22**	**13**	**10**	**17**	**27**	**21**	**27**

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
2nd Hour	**Partic.**	**Partic.**	**Partic.**	**Partic.**	**Partic.**	**Partic.**	**Partic.**	**Partic.**
Student 1*	2	2	2	1	1	0	0	1
Student 2*	0	0	0	0	0	0	0	0
Student 3*	0	0	0	0	1	1	1	0
Student 4	1	1	2	3	1	0	2	1
Student 5	a	1	a	0	2	0	a	a
Student 6*	0	0	1	1	1	2	a	2
Student 7	a	0	3	2	0	a	a	a
Student 8*	0	0	0	0	0	a	a	1
Student 9	0	0	0	0	a	0	0	1
Student 10*	a	0	0	a	0	1	1	1
Student 11*	0	0	0	a	1	1	1	0
Student 12*	a	0	2	0	1	3	1	2
Student 13	1	2	3	2	1	2	2	1
Student 14*	0	0	1	0	0	0	0	0
Student 15	4	3	3	3	1	3	2	2
Student 16	1	0	2	2	1	a	1	1
Student 17*	0	0	0	0	0	0	0	0
Student 18	4	2	2	4	1	1	2	1
Student 19*	3	4	4	4	1	3	2	1
Student 20*	1	0	0	0	0	0	0	0
Totals	**17**	**15**	**25**	**22**	**13**	**17**	**15**	**15**

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
3rd Hour	Partic.	Partic.	Partic.	Partic.	Partic.	Partic.	Partic.	Partic.
Student 1	0	0	0	0	0	0	0	0
Student 2	0	1	1	0	1	1	2	2
Student 3*	1	1	0	0	2	3	3	2
Student 4*	0	0	0	0	0	1	2	0
Student 5*	3	4	0	2	2	3	2	a
Student 6*	a	0	0	0	a	a	a	a
Student 7	1	1	1	0	1	2	3	2
Student 8	1	a	0	a	1	0	1	0
Student 9*	3	6	4	4	2	4	4	3
Student 10*	1	0	1	a	a	1	2	1
Student 11*	0	0	0	0	a	1	1	0
Student 12*	a	a	a	a	a	a	a	a
Student 13*	0	0	0	0	1	0	2	2
Student 14	a	1	0	0	1	2	1	2
Student 15	4	3	4	2	2	3	2	3
Student 16*	3	3	2	0	1	2	1	2
Student 17	3	3	4	3	a	3	2	3
Student 18	0	0	0	0	0	0	0	a
Student 19*	1	2	2	4	2	3	4	3
Student 20	1	3	4	3	0	1	a	2
Student 21	0	1	0	0	0	1	1	2
Totals	**22**	**29**	**23**	**18**	**16**	**31**	**33**	**29**

*Special education or ESL students

Total Participation by Day and Class Section

	Day 1	Day2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
1st Hour	17	22	13	10	17	27	21	27
2nd Hour	17	15	25	22	13	17	15	15
3rd Hour	22	29	23	18	16	31	33	29

Percentage of Students Responding

	Day 1	Day2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
1st Hour	43.8%	78.6%	50.0%	46.7%	93.7%	85.7%	81.3%	88.2%
2nd Hour	50.0%	35.0%	57.9%	50.0%	63.0%	52.9%	62.5%	66.0%
3rd Hour	61.1%	63.2%	45.0%	33.0%	68.7%	78.9%	88.8%	76.5%

APPENDIX C

Field Notes: Marine Biology Unit

Appendix C: Field Notes—Marine Biology Unit

Observation One
Topic: The Basis of Life: Algae

Opening questions:
1. What do all animals need to survive?
2. Where do they get some of those things?
3. What do you think is the most important living creature on earth?

Lecture: Presented information on the most common kinds of algae and their importance.

Notes: Most discussion and interest was due to opening question number three. A number of students described plants as being the most important creatures because they produce oxygen. No students discussed their role in the food chain (we had discussed that the previous trimester). There was low student participation during the lecture. No students asked clarifying questions. Interest was stimulated when we discussed how different kinds of algae are used in toothpaste, foods and cleaning products. Students seemed tired this morning.

Observation Two
Topic: Algae Gone Bad—Red Tides and Eutrophication

Opening questions:
1. What do you think could happen if there's too much algae (think yucky ponds)?
2. What causes algae to grow rapidly?

*During discussion, pictures of red tides and eutrophication were shown on a PowerPoint presentation.

Lecture: Presented information on red tides, causes and eutrophication

Notes: Pictures of red tides stimulated a few questions, such as: "Where do these occur?" "Can people swim in the water?" "What if you eat the fish in the water?" "Why are they so bad?" "Can they be other colors?" Lecture participation seemed about the same as the first day, but it was also a more difficult topic. I asked many questions and students responded, but many seemed reluctant to respond—it was like they responded simply so we could move on. Interest in the topic was about medium, there was some curiosity, but the interest seemed to wane as we moved on to eutrophication.

Observation Three
Topic: The Simplest Animals: Sponges

Opening questions:
1. (Showed pictures of sponges). Are these animals or plants and why?

Lecture: Discussed the characteristics of sponges, such as how they eat and reproduce

Notes: Student responses to the opening question focused mainly on what the sponges look like. Some students asked "how they get food", but they were in the minority (only three responses like that out of all the students who responded). We had discussed the differences between plants and animals before, but most students focused on anatomy other than physiological characteristics. Participation seemed very low as the material included many words that were new and unfamiliar. A discussion on how fans pull air into rooms related to how sponges pull water into their bodies generated the most discussion, but it was still difficult to get students involved. More interest was stimulated when we discussed how they reproduce (students always like to talk about reproduction). Many of the questions I asked were answered with simple answer, or I had to really lead students to think about how sponges eat and reproduce. We also compared sponges with people and talked about our similarities and differences.

Observation Four
Topic: Jellies!

Opening questions:

1. What do you know about jellyfish? What are some kinds of them?
2. In what ways are they beneficial?

Lecture: Discussed types of jellyfish, how they capture food, structures they have to help them eat and deliver toxins.

Notes: Students seemed to have more interest in this topic than some of the others. They asked questions about baby jellyfish, how they grow, what they look like, etc. Others asked about jellyfish stings and if urinating on a sting is an effective treatment. That question came up in every class section. After the lecture, a video on jellyfish overpopulation was shown and a short discussion followed. The kids didn't seem to really grasp very much of the video. The lecture involved a few difficult vocabulary words and concepts, so that could be why the students didn't ask a lot of questions. Most of their comments involved simple information we had learned before.

Observation Five
Topic: Deformed frogs in Minnesota

Opening story: Discussed the students in LeSeuer Minnesota that had first discovered the deformed frogs in 1986, and how they have since been discovered all over the world.

Discussion Questions:

1. Do you think this is an important issue?
2. Why would anyone care about deformed frogs?
3. Brainstorm at least three possible things that could be causing the frog deformities. Leave some space below each possible cause.
4. Below each possible cause, brainstorm some ways that you could test to see if that was actually responsible for the deformities.

Lecture: Discussed amphibian adaptations, reproduction, body structure

Notes: They students seemed very interested in the pictures of the deformed frogs that were shown during the news story. Overall, participation seemed very low. The questions required students to think more deeply about the issue and some students seemed reluctant to do so. Some of the students really got into the story, and I did notice that although discussion was less than it had been previously, the students really seemed to be writing a lot for their answers in their journals. They seemed more engaged with their journal questions than they have been otherwise. It also seemed that the lower functioning students had a hard time with the story, activity and questions. They seem to like a structured classroom environment, and this was out of the norm for them. Overall, the kids seemed tired during the lessons. We had a field trip the day before, so that could have affected their behaviors and attitudes.

For the first few questions, some students responded that only "frog freaks" would care about the deformities, but the last few questions revealed some deeper thought. Many students responded that environmental issues were causing the deformities, but they couldn't think of specific components of the environment. Some students even discussed damage to the DNA during development, which really surprised and pleased me. I was a little disappointed by the responses to question four because their experiments were very shallow and didn't show much thought. The idea of having a control came up in one class, but other classes had to be lead to that concept through our discussion.

Observation Six
Topic: "River dino," Reptiles and Birds

Opening Story: The class read a story about a mysterious reptile that has been spotted numerous times in the Southwest portion of the United States. The story involved eyewitness reports and a researcher's take on the mysterious sightings.

Discussion Questions:

1. Do you think the "river dino" is real? What evidence leads you to that conclusion?
2. What evidence would you need to prove or disprove the existence of the "river dinos"?
3. If this animal is real, what would convince you that it is a reptile and not another kind of animal?

Lecture: Discussed characteristics of reptiles and birds and the accuracy/credibility of news reports and eyewitness reports.

Notes: The kids seemed very excited and interested in this news report. This report was fairly long, but they kids overall were captured by the story. I even had one student attempt to sketch the mysterious reptile based on the descriptions provided in the story. I was also pleased that the students seemed to put a lot of thought into their responses for questions one and two. They gave substantial reasons for their beliefs and didn't just say "because" to justify their positions. A few students (about one-two per section) didn't substantiate their viewpoints, but when challenged, they were able to come up with some support. One student even shared an incident when his dad had seen a mysterious creature up north during a fishing/camping trip and had seen strange foot prints. As I've been doing these activities, I've noticed that inherently, there are greater opportunities to incorporate aspects of the nature of science and challenging questions. The stories naturally lead to those types of questions and thought, more so that the previous method did.

Observation Seven
Topic: Beached dolphins

Opening Story: The class read a story about a pod of dolphins that had been beached in shallow water; it was thought to have possibly been caused by a submarine using sonar. The real cause is still unknown.

Discussion Questions:

1. Why do you think the animals swam into shallow waters? What caused them to do so?
2. Why do you think so many died as a result? How did the shallow water affect their bodies? How would they be affected if they were washed ashore?
3. How could they adapt to survive such an event in the future?
4. What can be done to prevent similar events from happening again?

Lecture: Discussed characteristics of mammals

Notes: The students didn't seem quite as interested in this story as in the reptile one. They were more interested in the sonar and the submarine than what had happened to the dolphins. One student did mention some form of evolution for question three. A few students mentioned that they had seen dolphins and whales in the ocean before, so they were sharing personal experiences. The depth of the responses weren't where I'd like them to be, but I also feel that the questions weren't as probing as some of the other questions were.

Observation Eight
Topic: Avian Flu

Opening Story: The class read a news story about the avian flu epidemic during March of this year.

Discussion Questions

1. Why do not viruses usually travel from birds to humans?
2. The people of Hong Kong killed millions of ducks/poultry to attempt to contain the flu. Do you think this was the best way to deal with the problem? What other ways can you think of to deal with the possible flu pandemic?
3. How would you react if something similar happened in Minnesota? Would you recommend the same suggestions offered in question two?

Lecture: Discussed a little on bird physiology, body structure, travel, etc. and the culture of the Asian people as related to the quick spread of the illness.

Notes: The duck hunters in the class seemed to speak up more than some of the other students today. The first question didn't get very many good responses. A few students in each class remembered that viruses are usually species specific and cell specific, but they were the minority. For question two, most students came up with various ways of killing the animals and said that was the best plan because it was the least expensive way to get rid of the problem. Some talked about isolating the birds, but they also mentioned the difficulties in such a plan. It was interesting when we talked about it potentially happening in Minnesota. One student said that it wouldn't be probably such a big deal, because we do not live so close with our animals and most people do not eat duck often. This topic seemed to generate more responses than the mammal mystery, but it wasn't as engaging as the reptile story.