BACKROADS TO LEARINING:

THE USE OF NARRATIVES IN HIGH SCHOOL BIOLOGY

by

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Marcie Diane Reuer

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DEDICATION

This study is dedicated to my students: C.B.,C.B., A.C., S.D., C.E., M.F., J.G., P.K., J.K., A.L., M.M., H.M., J.N., J.N., A.P., M.S., A.W. for teaching me at least as much as taught you.

This study is also dedicated to Kenton and Dusty.

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ABSTRACT

This research paper is set within the context of the grade twelve biology class in Grande Cache Community High School, located in the Canadian province of Alberta. Many students lack adequate reading strategies to learn biology content from expository texts. A series of short stories about science, written in narrative form, was developed by the teacher. The question posed was: What is the effect of science narratives on content retention and interest in Biology 30? Average and low achieving students showed significant gains on exam performance, 10.9% and 13.9% increase respectively, and all cohorts of students indicated an increase in interest as determined by surveys, small-group interviews and an analysis of engagement during regular instruction and instruction using science narratives.

> "(I)n reading . . . stories, you can be many different people in many different places, doing things you would never have a chance to do in ordinary life. It's amazing that those twenty-six little marks of the alphabet can arrange themselves on the pages of a book and accomplish all that. Readers are lucky - they will never be bored or lonely."
> — Natalie Babbitt

INTRODUCTION AND BACKGROUND

For a lot of us, our most loved memory of learning began with a simple story book. Was it the time spent sharing the story with others, the nostalgia of our childhood, or simply our fanciful imagination that dreamed the story into life that made this learning enjoyable? For some of us this vision never died, but sadly, for some children their love of reading fades with maturity. The gradual replacement of stories that are personally relevant, with concise, precise, factual collections meant to expedite the learning process may be the reason for the slow erosion of enjoyment from reading. For many older students, learning becomes synonymous with memorization and their natural curiosity is buried under mounds of 'important' facts. The worthy cause of reigniting teenagers' passion for reading and learning is often a burden bestowed on the high school English department. All teachers must continue to stoke the embers of curiosity in their respective disciplines to achieve our ultimate goal: life-long learning in our students.

As a high school biology teacher, my literacy teaching has typically taken the form of instilling reading strategies for expository texts or assisting my students in memorization techniques so that they may recall the course content. Like any grade 12 teacher would tell you, my eye is continuously focused on the finish line, the government issued diploma exam that constitutes 50% of a student's final grade. Like anyone with a

basic understanding of science would tell you, the shortest distance between two points is a straight line. For these reasons I employed a model of efficiency in my classroom: the maximum amount of content in the shortest amount of time. The main tool to achieve this goal was the use of expository texts. Historically, my biology students have done well on government exams. The statistics revealed we had met our high standards together. It was true that I had some part in moving them from point A to B in their learning. They reached the finish line, but did they see the value of the knowledge they gained on their journey? Of this, I was not so sure. Perhaps there was another route that would take the students to the same destination, yet be more valued by the students. To alter our course, I decided to create a series of narratives .A science narrative is a nonfiction story, often based on historic or current events that encourage the students to apply content knowledge to a specific scenario. I initially suspected the narratives would make biology content seem more interesting, but would they help the students reach the same high standards on their diploma exam? To be honest, I had some trepidation. Over the spring 2011 semester I researched the following questions:

FOCUS QUESTION: What is the impact of science narratives on high school biology students?

- How will science narratives influence student retention of content for high, average and low achievers?
- How will science narratives influence student interest in biology?
- How will the use of science narratives influence classroom instruction practices?

And now begins the story of the narratives. To tell the story I will draw on some of my most loved stories to illustrate my study and underscore the value of the narrative

form. One of my most loved novels is C.S. Lewis' *The Lion, The Witch and the Wardrobe* (1978). The basic premise of the story is as follows: the Pevensie children must all contribute their unique skills to free Narnia from the spell of the White Witch. The theme of teamwork in the novel closely parallels the relationship that exists between the graduate student and their support team.

Academia's court consisted of three sons of Adam, two daughters of Eve and a single beast: Kenton Kaupp the Mathematical, Joe Bradshaw the Reader, Walter Woolbaugh the Counsel, Val Wright the Wordsmith and Dusty the Cat. With their guidance and support the icy, rigid grip of traditional teaching practice began to thaw. The emerging spring revealed unique forms of growth in all inhabitants. Academia's once desolate monotony, imposed by content, time constraints and accountability, juxtaposed the new-found enchantment. These architects of Academia helped break the very strong spell of the status quo.

The news of Academia will travel as far as possible. The events will be written, but more importantly spoken and shared with teachers and pupils alike. The hope of all hopes is that the events that transpired in Academia will become a small piece of its citizens, who will carry their knowledge forward….

CONCEPTUAL FRAMEWORK

The classic tale, The Wonderful Wizard of Oz, is a story about learning and personal growth. The iconic yellow brick road symbolizes the inherent ability to change our life's direction from the knowledge gained from our experiences. Each brick laid before eases

the travel and sets the direction. Similarly, knowledge acquired from those came before can help one fulfill his or her personal journey. While the road may not be complete, or may narrow in places, every piece of knowledge gained propels us forward. "I feel wise indeed…. When I get used to my brains I shall know everything" (Baum, 2008, p. 166).

The effect of narratives on memory and interest in science is interdisciplinary because it examines science in a humanities context. Consequently, the breadth of research for this project encompasses: research in neuroscience to determine the effects on memory; in linguistics to compare narrative and expository prose; in philosophy to determine how science's compartmentalization influences our collective and personal cultures; and in education to determine how narratives directly affect learning and motivation for students.

The major themes I investigated in my research were the definition of a narrative, the importance of narratives, the effect of narratives on memory and the effect of narratives on student interest and implementation strategies. An overarching theme discussed by the majority of articles was the role that narratives should assume in science education and the potential gains of this development.

What is a Narrative?

Narrative as an Artefact

A *narrative* is a type of prose with a structured syntax (beginning, middle and end) that communicates a linked series of events (Avraamidou & Osborne, 2008; Gange, 1978). A narrative must have a clear purpose (Avraamidou & Osborne, 2008). Reader attention is sustained because the reader wants to uncover the 'point' of the story (Norris,

Guilbert, Hakimelahi, & Phillips, 2005). The degree of reader attention elicited by the text is called *narrative appetite* (Norris et al., 2005). A narrative must also have an element of *agency*; a central character or object that participates in the events of the story (Avraamidou & Osborne, 2008; Norris et al., 2005). In science narratives, agency may take the form of human scientist trying to solve a problem or as an object, as a molecule of oxygen travels through the human body. Norris et al. (2005) suggest that a critical component of a true narrative is the presence of complications and resolutions; if these components are not present, the writing is classified as *descriptive prose*. The authors also assert that descriptive prose would likely not foster the same degree of engagement as narrative form (Norris et al., 2005). Avraamidou and Osborne (2008) offer a concise summary of the necessary components of a narrative (Table 1).

Table 1
Necessary Components of a Narrative (Adapted from Avraamidou & Osbourne, 2008)

Narrative Element	Description of element
Purpose	To help us understand the natural and human world. In the case of the natural world, narratives help the reader to invent new entities, concepts and some picture of the scientist's vision of the material world.
Events	A chain or sequence of events that are connected to each other
Structure	An identifiable structure (beginning, middle, end) where events are related temporally
Time	Narratives concern the past
Agency	Actors or entities cause and experience events. Actors may either be human or material entities who act on each other.
Narrator	The teller who is either a real character or alternatively, a sense of a narrator.
Reader	The reader must interpret or recognize the text as a narrative

A narrative can employ numerous literary strategies such as foreshadowing, punctuated timelines and metaphors to evoke interest in the reader (Miall & Kuiken, 1994; Norris et al., 2005). Although necessitating events must be linked by causal relationships in a temporal sequence, the writer of the narrative does not need to reveal events in chronological order (Norris et al., 2005).

Narrative is a term that many individuals associate with works of fiction. Some researchers call for a delineation between fictional narratives and non-fiction factual narratives (Genette, Ben-Ari, & McHale, 1990). In *factual narratives* the author must adhere to the truthful history of a set of events (Genette et al., 1990). Other terms that may be used to describe factual narratives are *science stories* (Metz, Klassen, McMillan, Clough, & Olson, 2007), *historical cases* (Stinner & Williams, 1993) or *explanatory narratives* (Millar & Osborne, 1998). I suggest a possible term to describe this genre is *faction*, a factual representation of events using literary techniques associated with fiction.

The narrative genre differs from the expository genre in many ways. An *expository text* presents information in topical form using concise and precise language to elicit a single interpretation of the content (Wolfe & Mienko, 2007). Conversely, a hallmark feature of a narrative is that it invites reader interpretation (Norris et al., 2005).

There is a common misconception that the narrative form cannot withstand the intellectual rigour and review that we commonly apply to expository texts. Howard (1991) suggests that the body of knowledge that constitutes science is a collection of stories and the process of science is a process of story refinement. For example, the 'story' of the atom has numerous authors; Dalton, Thompson, Rutherford, Bohr and

Schrodinger have all contributed to the currently accepted story of atomic structure. It is suggested that the separation of logic and narrative is misguided; logic and narrative are two sides of the same coin as logic can be classified as a type of story (Howard, 1991; Bruner, 1991).

Narrative can be used to describe information that is presented orally or textually.

Beyond 2000 (Millar & Osborne, 1998), a synopsis of the state of science education and a proposal for its new direction, emphasizes the importance of narratives in communicating the central ideas of the science curriculum.

Narrative-as-a-Method

Narrative can be used to describe the interaction between author and reader (Norris et al., 2005) or between numerous readers (Kozoll & Osborne, 2004). When *narrative* is described as an activity it is often called *narrative discourse* (Kozoll & Osborne, 2004). *Narrative* can play a large role in the creation of our self-perception. Our *personal narrative* may describe how we see ourselves or our perception of the world around us (Kozoll & Osborne, 2004). *Narrative-as-a-method* is of special concern to teachers as this strategy can be used to influence student engagement and the integration of science into students' personal experience.

For the purposes of this paper *narrative* will refer to factual narratives artefacts and *personal narrative* will refer to personal views and interactive experiences.

How do Narratives Affect Memory and Learning?

The primary goal of schools is to assist students in learning the necessary knowledge and skills so that they may function optimally in the real world. Many students identify that learning science is difficult (Negrete & Lartigue, 2004; Kaufman, 1997; Snow, 2010) and that there is too big of a gap between the scientists and their own capabilities (Negrete & Lartigue, 2004). Students provide many reasons for their perception of the difficulty of science. Oostheok (2007) finds that many students quit pursuing studies in the hard sciences of math, chemistry and physics earlier than interdisciplinary subjects like geography or archaeology. One of the main difficulties for students is a consequence of the concise, precise, grammatically difficult, high density-jargon-laden language of expository texts (Snow, 2010; Kaufman, 1997; Graesser, Hauft-Smith, Cohen, & Pyles, 1980; Negrete & Lartigue, 2004).

Numerous studies suggest that narrative text is easier to recall and understand than expository text (Gordon, 1978; Graesser et al., 1980; Yarkoni, Speer, & Zacks, 2008; Young & Saver, 2001; Claus & Kelter, 2006). Gordon (1978) found that definitions were the most difficult type of text to recall. It is not surprising that many students struggle with the expository emphasis on terminology.

Not all studies suggest narrative texts promote retention more effectively than expository texts. Negrete & Lartigue (2010) found that factual retention was higher for expository text than narrative text when recall was tested after one week from time of exposure; however, after two weeks the recall was slightly better for narratives than expository texts. The authors hypothesize that after a longer time period narratives may

fare even better than expository texts due to better long term recall of the story (Negrete & Lartigue, 2010).

Wolfe and Mienko (2007) found that there was no difference between expository or narrative text for learning, as evidenced by memory recall; however, they did find that amount of prerequisite knowledge required for optimal learning was higher for expository text than narrative text, alluding to the idea that narratives are easier to comprehend. The authors further delineate their findings by stating that subjects with lower initial knowledge learned best from the narrative text, while higher functioning subjects learned best from the expository text (Wolfe & Mienko, 2007). Zwann's (1994) experiment on the effect of genre expectations on text comprehension may provide a possible reason for Wolfe and Mienko's findings. The author presented the same text excerpt to subjects describing it as a narrative (literary story) for one group and as an expository text (news story) for the second group (Zwaan, 1994). He found that readers interpret text differently based on genre expectation; narrative texts focus on interrelationships, while expository texts encourage item specific processing, resulting in higher performance on recall tasks about specific details of the text (Zwaan, 1994).

Other researchers assert that using narratives in educational practice enhances learning because our brains are hard-wired to interpret narratives (Yarkoni et al., 2008; Young & Saver, 2001; Strube, 1994; Bruner, 1991). Bruner (1991) identifies that narrative comprehension is one of the first cognitive processes to developmentally emerge in children. This finding may suggest the primacy of this skill, or from an evolutionary perspective, narrative comprehension may be one of the most primal

cognitive thought processes. What follows is a brief discussion of the possible reasons why narratives may improve memory and cognition

Emotional Investment

Narrative may be easier to recall than expository text because the literary style of narratives is suspenseful, novel and amplifies emotions (Norris et al., 2005; Negrete & Lartigue, 2004; Solomon, 2002; Miall & Kuiken, 1994; Klassen, 2007; Hadzigeorgiou & Stefanich, 2000). This emotional response is confirmed by Young and Saver (2001), as the amygdalo-hippocampal system is activated during narrative reading; areas associated with emotional processing and long-term memory. Declarative memory, the conscious memory of facts and events about the world, is a type of long term memory (Squire, Knowlton & Musen, 1993) can be influenced by the meaningfulness of text to the reader (Johnson, 1973). The emotional interpretation of a narrative enhances reflection and dialogue in the reader (Negrete & Lartigue, 2004). The affective response elicited by narratives may account for the increased saliency of the information presented in narrative form.

Thematic and Temporal Syntax

Narratives may improve retention of content knowledge because a narrative can provide thematic scaffolding to an otherwise isolated series of facts (Negrete & Lartigue, 2004; Lederman, 1998). This natural categorization of information based on a temporal timeline may establish meaningful connections between the data (Strube, 1994). All narratives have an element of causality in time (Norris et al., 2005; Strube, 1994). In

factual narratives the temporal timeline is provided by the history of the events (Genette et al., 1990). By sequencing events in time, a learner can use this information to extrapolate the future (Claus & Kelter, 2006). If a narrative timeline does not align with the actual timeline because of literary strategies employed by the author, individuals do have the capacity to construct a correct sequence of events (Norris et al., 2005; Claus & Kelter, 2006). The unifying theme of narratives may provide an essential organizational tool for students to sort information, resulting in better recall or learned information.

The literary structure of narratives may also improve memory. At the beginning of any narrative there is in implied purpose (Norris et al., 2005; Strube, 1994). This purpose may provide the initial scaffolding for further learning. Narratives often present information concretely and the information is connected by causal relationships (Graesser et al., 1980; Avraamidou & Osborne, 2008). The syntactic structure of a narrative (beginning, middle, and end) can provide chronological account of events, with antecedent occurrences influencing the final outcome (Avraamidou & Osborne, 2008). Many narratives make continuous reference to initial events as a stylistic literary device (Norris et al., 2005); this continuous repetition may positively influence long term memory (Gagne, 1978). The literary nuances in the way narrative information is presented additionally encourage verbatim recall of passages (Negrete, 2003). The basic structure of a narrative emphasizes the learning goals to be sought by the reader, a feature not always evident in expository texts.

Concrete Visualization

Narratives may affect memory because the brain employs greater visualization strategies when processing narratives versus expository texts (Negrete & Lartigue, 2004; Kaufman, 1997). Children make pictures in their minds during silent reading or active listening of a narrative (Kaufman, 1997). Gagne (1978) suggests that vivid imagery through pictures or literary devices may have significant impacts on long term retention of information because pictorial stimuli are more salient than symbolic stimuli. Imagery is a common element of narratives (Norris et al., 2005), but is often lacking in expository texts. The association of factual knowledge with concrete images may make this knowledge base easier to retrieve.

Encouragement of Imagination and Interpretation

Narratives stimulate interpretation and imagination which may positively influence memory. The results of an experiment by Montague and Carter (1973) suggest that the degree of vividness of textual adjectives positively affects the recall of concrete information. Science expository texts typically shy away from any form of interpretative language and this may be a reason why the information presented in these texts is less memorable to readers than information presented in narrative form.

Narrative also transcends disciplines because the narrative form is capable of placing information in multiple contexts, resulting in knowledge integration rather than compartmentalization (Strube, 1994). The right hemisphere of the brain is stimulated by the imaginative features of a narrative (Hadzigeorgiou & Stefanich, 2000). Other research using fMRIs confirms that different parts of the brain are active during narrative

reading and expository reading (Yarkoni et al., 2008). Narrative information is processed in three main brain areas (Young & Saver, 2001, p.74):

> 1) amygdalo-hippocampal system, where episodic and autobiographical memories are initially arranged; 2) the left peri-Sylvian region where language is formulated; and 3) the frontal cortices…. where individual entities and events are organized into real and fictional temporal narrative frames.

The recruitment of additional brain structures during narrative reading was partially responsible for a 30% increase in the number of correct recall responses in one experiment (Yarkoni et al., 2008). This integration of information is the result of neural changes in numerous parts of the brain (Yarkoni et al., 2008; Young & Saver, 2001). The interdisciplinary nature of narrative texts allows for easier assimilation into existing knowledge (Strube, 1994), which may have a possible positive effect on memory.

A practical application of the interdisciplinary nature of narratives is that more instructional time can be devoted to instructional endeavours. Calfee and Bruning (2010) suggest that the No Child Left Behind policy, with its emphasis for language and math, has left little time for science in primary schools. By examining science from a literary perspective the amount of time devoted to science can increase substantially (Calfee & Bruning, 2010; Alberts, 2010). Additionally, an integration of science into the humanities may enhance student creativity.

Narratives can encourage critical thinking by suggesting indeterminacy in subject matter (Oostheok, 2007; Donnelly, 2004). Students must ask themselves, “what is ethical in this particular context?” These types of evaluate judgments constitute higher order

thinking skills on Bloom's Taxonomy and encourage students to pull from their factual knowledge base when making justifications.

The inherent interpretative nature of narratives aligns with the constructivist theory of knowledge acquisition (Zwann, 1994). Comprehension and storytelling are synonymous (Young & Saver, 2001; Telling Science Through Stories, 1991) as individuals must construct their own reality based on their knowledge (Turner, 1996; Carter, 1993; Howard, 1991.) During reading, readers begin formulating questions and then answering these questions as the reading progresses, during group discussion or further analysis (Metz et al., 2007). Bruner (1991) asserts that narrative is not merely an account of reality, but a method of constituting reality. Stories form the basis of cognition; infantile amnesia is theorized to exist because young children cannot yet form stories (Young & Saver, 2001; Squire et al., 1993). One may extend this line of reasoning further by suggesting that if stories form the basis of cognition, cognition could be improved if incoming information was presented in narrative form.

Part of the success of the narrative may come from its ability to activate the students' prior knowledge by providing a context to the science (Gange, 1978; Metz et al., 2007). The activation of prior knowledge is a key feature of J. Anderson's *elaboration hypothesis*, where a more substantive content base elicits more elaboration (Gagne, 1978). Prior experience acts as initial scaffolding for further learning (Metz, 2004); however, the degree of familiarity with information presented in a narrative had little effect on content retention (Graesser et al., 1980). In this study, recall performance, as determined by three alternative forced choice questions, was compared for a familiar narrative, an unfamiliar narrative, a familiar expository and an unfamiliar expository

(Graesser et. al, 1980). The results only show a correlation between retention and text type, narratives out-performing expository, with familiarity having insignificant effects on retention (Graesser et. al, 1980). Despite contradicting evidence regarding the direct relationship between prior knowledge and memory, an indirect relationship may exist- if a prior knowledge base is activated during reading this may make the reading experience more enjoyable or provide the reader with increased confidence, both of which may have positive effects on memory.

Cultural Bias

Narratives are deeply entrenched in our everyday encounters. Almost all social interactions are a form of narrative. This cultural bias towards narratives may suggest why this communication form has been shown to positively affect memory (Ramsey, 2005). Our self-perception is founded on the basis of many narrative experiences and our functional communication with others is a form of narrative discourse (Ramsey, 2005). As oral narratives were a primary form of communication and account of history for thousands of years, it is not surprising all human groups have a propensity towards this literary or oral communication form.

Numerous variables may account for the positive correlation between narratives and memory. Emotional investment in the narrative may prime the reader for content retention. The information presented in a narrative may be arranged in such a way that it provides a basic comprehension structure for learning. The literary artisanship of the narrative stimulates different brain structures than expository text which may increase the saliency of this information in the memory. Imagination and interpretation may induce

factual recall as the reader mentally dialogues with the text while reading. And perhaps, the most obvious reason for our brain's affinity for narratives is because we are already accustomed to them. It is likely the strength of the aforementioned factors is not equal, but it is likely all factors influence memory to some degree.

How do Narratives Affect Student Interest and Motivation?

Before discussion on the influence of narratives on student interest and motivation, one must first discuss students' current perceptions of science as a field of study and science as subject matter. Negrete and Lartigue (2004) state that science has "an image problem" (p.8). Many students identify that science texts are difficult to understand (Snow, 2010; Negrete & Lartigue, 2004). They see the density of information and heavy use of terminology as major obstacles to their success. Not surprisingly, many students feel they are not capable of learning science (Negrete & Lartigue, 2004; Oostheok, 2007). When post-secondary, humanities students were surveyed about their reluctance to take science classes, the two most common responses were that they perceived science as *difficult* and that they were *not good at it* (Oostheok, 2007).

Many others identify science as dull, boring, irrelevant and pointless because all the answers are already known (Negrete & Lartigue, 2004; Oostheok, 2007). Many researchers cite students' disenchantment and disengagement with science is due to a lack of context (Negrete & Lartigue, 2004; Oostheok, 2007; 19). Factual narratives can provide a context for science content and alter the teaching delivery method so as to make it more enjoyable for students.

Science as Autonomous, Interpretative, Imaginative

In the same survey by Oostheok (2007) nearly 40% of the students indicated a reason they did not like science was because there was the lack of discussion. It has already been established that narratives provide a discourse between the author and the reader and that the narrative can be used as a group discussion starting point (Stinner, McMillan, Metz, Jilek, & Klassen, 2003; Metz, 2004). The fact that multiple interpretations can exist may function to stimulate dialogue between individuals (Ramsey, 2005). The foundation of storytelling is a communal enterprise. If individuals engage in a meaningful discourse about a narrative they may make judgements that contribute to their worldview (Kozoll & Osborne, 2004). This discourse can also emphasize the relevance of science in the everyday lives of students (Oostheok, 2007).

Narratives allow science content to become interactive (Hadzigeorgiou & Stefanich, 2000), while expository texts often encourage reader passivity because they are authoritarian in nature (Negrete & Lartigue, 2004). Many articles that discuss the practical implementation of narratives in science education identify the interactive, social component of narratives as being critically important to the learning cycle (Stinner & Williams, 1993; Stinner et al., 2003; Klassen, 2007; Metz, 2004; Metz et al., 2007).

Narratives allow for multiple truths (Negrete & Lartigue, 2010); by allowing students to individually interpret content their autonomy is increased (Donnelly, 2004). Instead of being passive recipients of science, students can feel as though they are navigating the content. Bruner (1991) states that, “Interpretation is concerned with “reasons” for things happening, rather than with their causes,” (p.7). A possible interpretation of this could be a student asking “what reasons did Darwin have for waiting

so long to publish On Origin of Species?" In this scenario the humanistic, emotional and societal influences are considered more deeply than the direct cause and effect relationship presented in many science texts. If scientists are perceived as human, with strengths and weakness, students are encouraged to empathize with them (Solomon, 2002; Young & Saver, 2001). Revealing the personal lives of scientists through narratives may increase interest in science by making it possible for the students to personally identify with people that have contributed to our scientific body of knowledge.

The use of vivid imagery through pictures or literary devices also increases student engagement by stimulating the imagination. A criticism of current science educational practice is that imagination has been largely ignored (Hadzigeorgiou & Stefanich, 2000). Metz (2004) attributes this to verification type lab activities while others attribute it to the authoritarian nature of science texts (Negrete & Lartigue, 2004). Science presented as a collection of facts is not appealing to students. Kubli (2005) observed that "bare bones do not make an appetizing meal" (p.520). By allowing students to use their imagination, a sense of authorship of their learning is encouraged. Additionally, many students positively regard tasks they deem as creative enterprises.

By activating the higher faculties of interpretation and imagination in students a likely consequence will be greater student engagement in science. Learning facts in isolation is time consuming, boring and does not encourage personal investment (Negrete & Lartigue, 2004). Narratives are a tool to humanize and contextualize science with a secondary effect of making science more enjoyable to learners (Claus & Kelter, 2006).

Interest as a Consequence of Literary Structure

Expository texts are often seen by students as a series of unrelated facts (Negrete & Lartigue, 2004). The organizational structure of expository texts is not always evident to readers. Conversely, most narratives have a clear purpose (Norris et al., 2005) and students can readily identify this purpose when reading. Stinner and Williams (1993) have observed that students are responsive to information with a central unifying idea.

Two elements of narratives, causality and agency, encourage investment by the reader (Norris et al., 2005). Narratives pique students' natural curiosity, motivating them to see what happens next. Students also interpret outcomes in a narrative by considering the necessitating causes (Norris et al., 2005). In this type of interpretation the reader must consider personal motivations, contextual variables and situational constraints of the characters involved. Science narratives can reveal factual information in such a way that readers are motivated to "understand the science behind the plot" (Miller, 2010, p. 748). If the main goal of reading is to understand the point of the story, it is not surprising that students would be motivated to understand as much of the context as possible by interpreting the science content.

Miall and Kuiken (1994) noted longer reading times for narratives than other types of text. This may be due to the high degree of processing required for considering multiple perspectives or making personal ethical judgments about the story.

Science as an Attainable, Relevant, Worthy Pursuit

Perhaps the most primary goal of science education is for students to see the value of science in their everyday lives. In a student survey by Oostheok (2007) 20% of

respondents said that they do not need science, while 25% said they need it only occasionally. In a study by Kozoll and Osborne (2004), migrant agricultural workers in postsecondary school were interviewed to determine their views of science and the personal relevancy. One student expressed that he didn't "need science for his life or his future" as he was not pursuing a career in the sciences (Kozoll & Osborne 2004, p.166). I suspect this view is one held by many students.

Narratives can reassert scientific relevancy to students in their personal lives by showcasing the interaction of others with science (Stinner et al., 2003). Eldredge (2009) identifies a relationship between personal relevance and actual learning. By showing science in context, students can extend gain insights into the types of contexts they may encounter where their factual knowledge might be useful. Narratives may be an appropriate mechanism to encourage the integration of science into the realm of everyday thought (Kozoll & Osborne, 2004). This is an important prerequisite in fostering informed citizenship in students (Carter, 1993).

Many students become disengaged with science because they see it as beyond the scope of their intellectual capabilities (Negrete & Lartigue, 2004; Carter, 1993). Science is not going to be an appealing endeavour to students if they feel it highlights their academic deficiencies. Hiller (1974) as referenced in Gagne (1978) found that students with high academic confidence had greater recall of information; Gagne (1978) hypothesizes that this may be due to increased persistence. If students perceive the content base of science as so difficult that it is not worth attempting we have failed in our most basic pursuit of basic scientific literacy. We cannot possibly teach students who have 'checked-out' of science.

Narratives are a delivery mechanism that can communicate factual information in a more comprehensible way than expository texts (Gordon, 1978; Metz, 2007). If students are given a taste of success, it would follow that this may increase their academic confidence and further performance. Norris et al. (2005) states that a possible reason why comprehension for narratives is higher is may be due to the fact that primary literacy education focuses almost exclusively on this literary form. This discussion also cautions that the extensive use of narrative in science may compound students' inability to properly negotiate expository and argumentative texts (Norris et al., 2005). While Norris presents a logical argument, engagement with the subject matter is a prerequisite before any type of learning can occur.

By considering some of the philosophical underpinnings of science students can begin to answer the basic questions of: "Who am I? Where do I come from? How do I fit into the scheme of things?" (Eldredge, 2009). Strube (1994) identifies that narratives are an important component of self-identity. If we present science in narrative form that is appealing to students there is an increased likelihood science will become a part of their personal narratives. He states, "we are, in effect, quite literally the stories we tell," (Strube, 1994, p. 318). If we are to foster scientific citizenship, science cannot be presented as a series of unrelated facts; it needs to be made meaningful to the students (Millar & Osborne, 1998). Kozoll and Osbourne (2003) identify that students have difficulty finding meaning in science even though they may be proficient in factual recall. Students should integrate science with their personal experience so it can become assimilated to their worldview (Kozoll & Osborne, 2004). Narratives allow for interpretation and reflection (Hadzigeorgiou & Stefanich, 2000) which moves science

from a sterile concept (Kozoll & Osborne, 2004) to one that is personally meaningful. We must be cognizant of how science instruction influences the personal narratives of students. A large body of factual knowledge will be of little legitimate importance if students fail to see its value in relation to their own attitudes, values and beliefs.

Students are likely to continue to disregard science as a foreign entity; separate, irrelevant and unattainable, unless science education can increase interest in science. For science to be valued it must become a part of the collective culture. During the Space Race, science was an integral part of our collective identity (Maher, 2009; Wang & Marsh, 2002). Numerous science narratives, albeit fictional, such as *Planet of the Apes* and *2001 A Space Odyssey* captured the imagination of students and presented science as a world of possibilities. The narrative could be re-employed as a factual dissemination tool to reignite the minds of our students.

Strategies for Implementation

Numerous papers exist outlining some practical implementation methods for using narratives in the science classroom. The first task that must be accomplished is finding or creating a good narrative. Good narratives should extend the content of the textbook, include biographies of scientists (Stinner et al., 2003) and activate the prior knowledge of the student (Metz, 2004; Metz et al., 2007; Stinner & Williams, 1993). The purpose of the narrative should be explicit and organized thematically (Stinner et al., 2003) around one central idea (Stinner & Williams, 1993). Narratives should address historical and contemporary issues (Metz et al., 2007) that make reference to the philosophy of science (Stinner & Williams, 1993). A narrative should integrate science

content (Oostheok, 2007), but this content should reveal itself naturally in the course of the story (Stinner & Williams, 1993). When a reader is reading a narrative the narrative should stimulate reader questions (Metz, 2004) and encourage the reader to make generalizations about the content (Stinner & Williams, 1993). Klassen (2007) suggests a possible model for the narrative learning approach (see Figure 1).

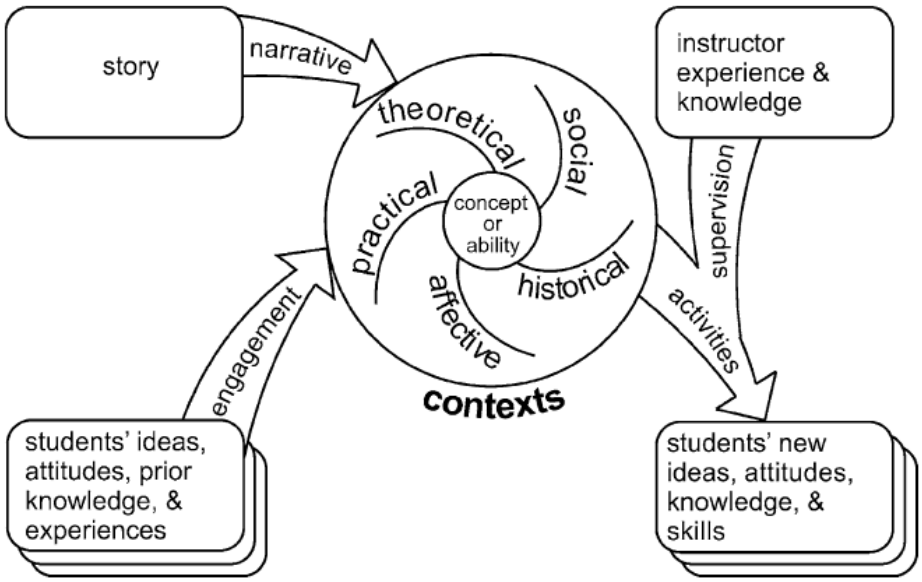

Figure 1. A Schema for the Story-Driven Contextual Approach (Klassen, 2007), Reprinted with permission (Appendix I).

Good narratives are difficult to find and hard to produce. Stinner and Williams (1993) suggest the construction of a narrative should be a joint effort between the instructor and the students. Norris et al. (2005) maintain that science narratives should try to retain as many of the literary stylistic components of fictional narratives in order to reap the benefits of the narrative.

There are some varied approaches to implementation of narratives in the science classroom. A number of papers identify three phases of the learning cycle; initial interaction with the narrative to activate prior knowledge; group discussion of issues and themes; and finally, a historical experiment that mirrors one presented in the narrative (Metz, 2004; Metz et al., 2007). Other opportunities for students to respond to the narrative may also include writing activities for reflection (Metz et al., 2007).

Narratives can be used for a variety of purposes. Kubli (2005) suggests that short stories may be used as "door openers" to begin instruction. The primary purpose of these narratives is to evoke interest in the subject matter rather than explain a large volume of scientific content (Metz et al., 2007). Conversely, the storyline approach is a large overarching thematic approach to disseminating an extensive content base (Metz et al., 2007). In the storyline approach the narrative is delivered in small segments over the course of many lessons and continuity is achieved by a central theme (Metz et al., 2007; Metz, 2007).

Additionally narratives can be presented textually or orally, depending on the learning goals of the classroom.

The integration of narratives into science education is one of degrees; a narrative may be used as one of many instructional tools to engage learners or it may provide the structural basis for a unit of study.

Other Applications of Narratives

Harris (2000) describes how technology will likely influence narratives. He asserts that narrative will be redefined where the temporal order of the narrative is not

provided by the author, but rather navigated by the readers as they navigate the material through a series of hyperlinks (Harris, 2000). This type of narrative would encourage greater reader autonomy as the reader navigates the narrative according to their individual preferences and values. Harris (2000) notes that the hierarchical organization of websites reveal to a reader the overarching concepts first followed by more specific details. Lists are used as preview techniques to allow the reader to determine the completeness of information on a page (Harris, 2000). There is great opportunity for this form of narrative to flourish as young people become more aligned with technology. There is little doubt that technology influences the personal narratives of students, particularly applications like Facebook and Twitter. If science could alter its format to be compatible with these technological mediums, it is more likely the content will be appealing to students and consequently, more likely to become integrated into their personal worldviews.

Snow (2010) cites that many students prefer reading websites to books. Marshall McLuhan identified that the "medium is the message." Hypertext will alter how narrative is communicated and will consequently alter the way students interact with science. Future research in this area would be of great educational value.

Why are narratives important?

The current research examines numerous reasons for the use of narratives in learning situations that are not directly related to my study, but are of importance nonetheless. Most of the discussion involves the high degree of compatibility between narratives and the foundational emphasis of nature of science and scientific inquiry

(Metz, 2004; Negrete, 2003; Lederman, 1998). Metz (2004) observed that most science experiments performed in school serve to only verify scientific laws. Lederman (1998) supports Metz by stating that performing science experiments is not necessarily synonymous with scientific inquiry, a common misconception among science teachers. In these scenarios, science education readily provides the answers, but does not give the student an opportunity to pose questions. A narrative can provide an authentic stimulation to the students to form questions as they read. Most narratives are not as explanatory in nature as expository texts; they encourage some degree of learner autonomy (Negrete, 2003; Donnelly, 2004). Textbooks tend to present information in "final form" and neglect to adequately show the scientific process (Negrete & Lartigue, 2004; Metz et al., 2007; Negrete, 2003). Negrete and Lartigue (2004) ascertain that textbooks are authoritarian in nature and misrepresent the culture of uncertainty that spurs on scientific investigation. The factual account of science without context in science textbooks misrepresents science as a completely linear endeavour, when in reality science involves a great deal of creativity (Norris et al., 2005; Lederman, 1998). Nature of Science and Scientific Inquiry are core goals of science education that could be addressed through the use of narratives.

The use of narratives in science can help present science in a societal and historical context (Metz et al., 2007; Negrete, 2003; Frappier, 2006; Bower & Clark, 1969). Context is vitally important to understanding the purpose of a piece of knowledge and the value of it. A pen is only meaningful in the context of paper. By pairing the pen with paper, the purpose of the pen becomes evident. A possible extension of this analogy could be that a tool without a purpose never gets used; similarly, a piece of knowledge

without a purpose is likely to be forgotten. Context not only illustrates the purpose of knowledge, but also identifies situations where knowledge may be useful. The learner will be more likely to apply their knowledge if they have an initial context to use as a reference. By examining science in a historical context, students get to witness the scientific process in an authentic scenario (Negrete, 2003). Bruner (1991) states that history is an accrual of many narratives. May this logic also extend to our collective body of scientific knowledge? If so, it would seem only fitting that the history of science be taught using narratives.

The overly simplified representation of scientific history in many textbooks ignores the contributions of other societal factors. Imagine if a humanities textbook presented the disintegration of the USSR as follows: "the USSR was replaced by a commonwealth of independent states"- it is absurd not to consider the societal and political events that led up to such a historic moment. In science education, however, this practice is commonplace; "Thompson's atomic model was replaced by Rutherford's". Metz (2004) summarizes Rutherford's assertion that the history and philosophy of science are not taught, student understanding will be compromised. Donnelly (2004) denotes the importance of the STS (science, technology, science) movement is critical for students because it emphasizes the human purpose of science while addressing ethical issues. Narratives can delineate important societal influences on science and integrate information that is commonly presented in isolation in expository texts (Norris et al., 2005). Narratives can be a tool to paint the societal and historic landscape of science to foster greater understanding in students.

Narratives can also be a tool to promote scientific citizenship in students. Solomon (2011) identifies that narratives can be the basis for an ethical dialogue. The narrative can be used to raise issues and the students can discuss perspectives and make evaluative judgments on the issues based on their values (Solomon, 2002). The ethics of science is always relevant; just because science *can* progress in a direction doesn't necessarily mean that it should. An excellent example of narrative stimulating ethical discussion is Holocaust on Trial (WGBH Science Unit, 2000). The Holocaust on Trial is an online narrative that presents some of the science experiments performed by the Nazi's on the Jews (WGBH Science Unit, 2000). The central thematic question is "should the results of these science experiments become part of the collective scientific record?" Students should have opportunities to make ethical judgments on scientific issues if they are to be informed citizens. When using narratives in the classroom there is a natural dialogue between the author and the reader (Solomon, 2002) and secondary dialogues can result if students are given the opportunity to respond to what they have read in a collective environment (Bruner, 1991). The natural discourse elicited by narratives is a foundation of scientific literacy. Students must be prepared to form their views based on a reliable content base, make political and consumer decisions based on their views and be able to defend these views to others.

Narratives encourage a contextual presentation of science. This context helps to foster nature of science (NOS) and scientific inquiry (SI) goals in the classroom. Prior to doing this research I did not account for the influence of narratives in these critical areas. Consequently, NOS and SI were primary considerations when field notes were collected.

Narratives also act as a starting point for ethical dialogue surrounding relevant issues. An interesting perspective was also presented by Kozoll and Osborne (2004) regarding the delivery method of science to students; science classroom delivery methods directly affected students' personal narratives with science. Narratives may be able to bridge the gap between a foreign content base and students' personal lives.

In conclusion, there is a significant amount of research that suggests narratives improve student engagement (Negrete & Lartigue, 2010; Metz, 2004; Metz, 2007; Metz, Klassen, McMillan, Clough, & Olson, 2007) and memory (Stinner & Williams, 1993; Solomon, 2002; Stinner, McMillan, Metz, Jilek, & Klassen, 2003). There is an increasing emphasis on teaching science in a historical context. The interdisciplinary approach of teaching science underscores the relevancy of science in the real world for students. This is becoming an emergent issue as curriculums expand and require students to know a wide content base. Students need something to pull them back into science, pique their natural curiosity and help them see the applicability of their science skills beyond the walls of the classroom. Science narratives were used to address these goals.

METHODOLOGY

Another favourite book of mine was Mrs. Frisby and the Rats of NIMH. Central to the rats' superior intelligence and functional society was their understanding of science and their fully literate society. "The Plan" of the rats was to abandon their lifestyle of dependence on humans and begin their own colony.

"The Plan" for Ms. Reuer was one of independence for her children, where they would cross the threshold of adulthood and possess the skills for full autonomy. In her

discussions with the other 'rats', most shared her vision, but the details of "The Plan" often caused divisions in the colony. Factions of rats split off, following different leaders; some were successful, while others experienced hardship. Over the coming months Ms. Reuer and her children busied themselves in the details of "The Plan". She often worried that "some might grumble at the hardness of the new life" (p.228) she chose for them. Always weighing on her mind was 'the plough'; its annual appearance determined which rats made it and which rats didn't. It was "on a day in May as warm as summer" (p. 229) that Ms. Reuer realized her children had the skills for autonomy. Although 'the plough' claimed one rat, the others, as she hoped they would, thrived.

Grande Cache is a rural town of approximately 3,700 residents located in the foothills of the Rocky Mountains. The main employment sectors are mining, energy production, oil and gas extraction, and forestry. According to the Alberta Community Profile, 22% of residents do not possess a certificate, diploma or degree, compared to 15% in Alberta (Alberta Community Profiles-Grande Cache, 2006). The post-secondary education attained by most residents is in trades education; 4% of Grande Cache residents possess a bachelor's degree, compared to 15% in Alberta (Alberta Community Profiles-Grande Cache, 2006).

The study group for this research project were eighteen grade twelve students enrolled in Biology 30 at Grande Cache Community High School. I taught this particular group of students for four years in a variety of subjects. The ethnic composition of this class is roughly comparable to the ethnic composition of the rest of the school; however, there were no self-identified First Nations, Metis, Inuit in the study group; 84% Caucasian Canadian Citizens, 6% South African Landed Immigrants, 6% Eastern

European Landed Immigrants and 6% Asian Canadian Citizens. The sample was gender biased towards females with only 1/3 of the study group being male. The socioeconomic status of this group varies considerably amongst the students' families. This study was conducted February 2011- June 2011. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

I wrote set of eight narratives for corresponding chapters in the Biology 30 accompanying text. The goal of the narratives was to present an interesting historical or contemporary story that aligned with the curriculum for a given topic. Obscure topics that students may not have had any previous experience with were used to provide novelty. The current research suggests that novel information is often more appealing and persists in students' memory more than that which is familiar (Kubli, 2005).

The technique used to implement the narratives was a hybrid between Kubli's (2005) narratives as "door openers"; where a narrative is used only to introduce a topic and initially engage the students and Stinner and Williams' (1993) "large complex problems" where the narrative acts as thematic foundation for additional assignments. Logistically, the students were given the narratives, which they read individually and the teacher moderated discussion and addressed questions the students had regarding the context presented in the narratives. For my treatment I used the narratives as a door opener, but also as preliminary scaffolding throughout the lesson. As the students learned more and more content they were challenged to investigate the seemingly simple narrative in deeper and deeper levels of analysis; for example, the students read a narrative on the Goat Gland Doctor (Appendix A) at the beginning of our reproduction

unit. Most students were curious to find out if the goat glands would have actually delivered Dr. Brinkley's claims. After learning content, such as the negative feedback loop for testosterone, the students uncovered some of the problems with Dr. Brinkley's science. Other subsidiary science concepts such as reliability and validity and the nature of the placebo effect were also discussed. By the end of the chapter students were able to complete a comprehensive analysis of the narrative using proper terminology and appropriate content.

Controversial issues addressed by the narratives often challenged students to incorporate science content into their world view. The narratives "The Upper Crust", "Growing Despair" and "The Most Dangerous Game" (Appendix A) have contentious subject matter that requires scientific and moral analysis. For example, many students in Grande Cache participate in hunting, but few considered the implications of our current game management strategy where the 'biggest, best and most mature' animals are artificially selected by humans. While most of the students in the course had a good understanding of evolution, they failed to see their actions as an evolutionary pressure on the animal populations in our area. These narratives were used as a starting point to encourage students to synthesize their opinions and modify those opinions in light of the scientific knowledge. The narratives, in these scenarios, served as a springboard for debate amongst the students. The role of the teacher in this scenario was to act as a moderator and pose questions such as "do you feel Darwin would agree with what you are saying?".

The narratives were also used as a context for the students to apply their skills. The narrative "First Do No Harm" (Appendix A) was used as a context for students to

apply their knowledge of pedigrees. Students were taught how to interpret pedigrees and reason out unknown genotypes prior to exposure to the narrative. After reading the narrative students analyzed a pedigree representing a family with fatal familial insomnia. The goal of this technique was twofold; teach students *how* to use pedigrees and *when* to use them. The first goal, easily accomplished by worksheets, develops a skill in isolation; its relevance to the students could be described as obscure at best. The second goal requires the teacher to provide an authentic context; if students encounter a similar context in the future it is probably much more likely they will retrieve their knowledge and apply it to the new situation. Teaching science in context not only encourages transference of knowledge to new situations, it underscores the relevance of the knowledge itself. In summary, the narratives were often used to address the age- old questions of "why are we learning this?" and "when will we ever need this in real life?".

Over the semester eight narratives were administered to the students with my usual litany of regular teaching practice (direct instruction, assignments, labs, videos, web Quests, projects) acting as baseline instructional techniques. A variety of quantitative and qualitative analysis techniques were used to measure the effectiveness of the narratives and are compiled in Table **2**.

Table 2
Data Collection Matrix

Student Retention	Teacher made chapter exams and quizzes	Provincial Diploma Exam	CAT data / Student surveys	Interview
Student Interest	Tally Number of Questions asked during narrative vs. regular direct instruction	Tally of Number of different students asking questions	Student Survey	Interview
Effect on Instructional Delivery	Teacher Field Notes	Teacher reflective journal	Video tape: % time teacher vs. students talking	

To test the retention of course content multiple choice and numeric response chapter tests and the government issued, summative Diploma exam were analyzed. Questions were divided into those addressed by the narratives and those addressed by other techniques. The information is summarized in Table **3**.

Table 3
Quantitative Analysis Strategies for Measures of Content Retention

Analysis Strategy	Goals
Chapter Tests-Whole Class Average: determine the % of questions correct for the narrative vs. regular instructional activities	Obtained holistic picture of student performance on narrative content vs. content covered by traditional teaching methods
Chapter Tests-Analysis of cohort groupings. Cohort classifications are based on the students' performance on their Biology 30 blended grade. The cohorts are identified as follows: • 80%-100%- "high achievers" • 60-79%- "average achievers" • 0-59%- "low achievers"	Determined which cohort benefited the most/ least from the narrative by comparing performance on narrative questions to performance on questions not covered by the narrative.
Chapter Tests-Individual student analysis	Individual results across the trials were compared to show which narrative was the most effective for each student. This information was then compared to a survey where students ranked their narrative preference to determine any possible correlation between interest and performance.
Provincial Diploma Exam	Summative exam was used to determine if a narrative effect was present, did it diminish over time by comparing performance against chapter tests.

The quantitative instruments of the chapter exams and diploma exam are highly reliable. The multiple choice and numeric response questions of the government issued diploma exams are field tested for validity and reliability on very large sample sizes (n=>500) (Mitchell, 2011). Each question is then statistically analyzed after the exam to ensure the effectiveness of the distractors, determine the degree of difficulty (expressed as percentage of students in Alberta that chose the correct response) in addition to ensuring certain sub-groups, such as high achievers, chose the correct responses.

Approximately 60, 000 students write the Biology 30 Diploma exam each year (Mitchell, 2011); therefore, it can be assumed a statistical analysis of this large sample size would yield reliable results. To ensure the same validity and reliability for teacher made exams, multiple choice and numeric response questions were used from archived Diploma exams.

The quantitative data in addition to qualitative data obtained from surveys, focus group interviews and two sentence summaries. Focus groups were interviewed after the first narrative and again at the end of the semester to obtain first and final impressions. The results of the interviews were thematically grouped and analyzed. Students were administered three surveys throughout the semester; the first survey was given after the first narrative, the second survey was given after the fourth narrative and the final survey was given after the eighth narrative (Appendix B). Students were also required to complete two sentence summaries and give recall ratings to each of the narratives. The CAT data were collected after the fourth and eighth narrative (Appendix C).

To determine the effect of the narratives on student interest in biology a number of quantitative and qualitative techniques were employed. There is a significant amount of research that suggests teaching science in context increases inquiry based learning. Metz (2007) identified that traditional teaching methods often provide students with the answers before letting them formulate questions. As one measure of student interest, the class was videotaped while they were responding to the narrative. Baseline data was also collected during the second half of the lesson that used direct instruction. After the lesson, the video tape was analyzed to determine the number of questions asked by the number of different students for the narrative response and for the direct instruction

segment. These values were expressed as number of questions per minute and number of different students asking questions during each lesson segment. It was assumed that the number of questions asked is a functional measure of student interest as determined by their engagement during the lesson segment. The number of different students asking questions provided insight into the proportion of the class engaged in the lesson as some students are only motivated to take part in class discussions if it is a topic that really interests them. This measure allowed the researcher to investigate if the narrative treatment is well suited to the majority of students. It can be reasoned that the narrative strategy is only broadly applicable if a large cross-section of the students are engaged. This measure is more revealing than simply tallying the number of questions because it is possible to have many, many questions come from only one interested student.

Interest level was also gauged qualitatively in the small group interviews. Students identified what they liked and did not like about the narratives. The groups consisted of a high achieving student, an average achieving student and a low achieving student. Throughout the course of the semester, the students performed several tasks together to increase their comfort level with each other.

The students were also given the opportunity to offer suggestions for improvement (Appendix D).

To determine the effect of this treatment on instructional delivery three techniques were used. Firstly, the video tape of the narrative segment of the lesson and the non-narrative segment were compared to determine the amount of time the lesson is directed by the teacher and the amount of time it is directed by the students. This measurement will be expressed as a percent. The remaining two measurement techniques were self-

reflective in nature. Teacher field notes were recorded immediately following each intervention (Appendix E). The notes described what happened in any given lesson. The actions of both the students and the teacher were described. The field notes were analyzed continually throughout the intervention to determine if small variations in instructional delivery had any effect on the effectiveness of the narratives for the students. Trends were thematically analyzed at the end of the semester. A reflective log was also kept during the semester. The teaching reflective log focused on how the treatment impacted my teaching personally (Appendix F). A thematic analysis of this instrument was also performed at the end of the semester.

The following sampling timeline was used in this research project.

Table 4
Sampling Timeline

Narrative #	1	2	3	4	5	6	7	8
Videotape	X	X	X	X	X	X	X	X
Chapter Exams	X	X	X	X	X	X	X	X
Survey	X			X				X
Interview	X							X
Field notes	X	X	X	X	X	X	X	X
Reflective journal	X	X	X	X	X	X	X	X
Summative Diploma Exam								X
Narrative Ranking								X
Narrative classification by colleagues								X

As I wrote the narratives I realized that there were a considerable number of variables in the format of the narrative itself. I experimented with different writing styles and altered the narrative form. Some had the same degree of narrativity throughout, some had opening vignettes, while others were more biographical in nature. After all the

narratives were complete I asked the students to rank the narratives for both interest and retention (Appendix G).

At the end of my final treatment cycle I performed a meta-analysis of some of the data gathered for other purposes. I studied how variables such as reading level, word count, student interest level and student perceived retention level (as gathered from the interest rank survey), teacher narrativity classifications (Appendix H) compared to the overall exam performance for each section of content covered by each particular narrative. The goal of this study was to determine which narrative features had the strongest correlation with exam performance to help address the question: What narrative characteristics are the most effective at increasing exam performance? This information could later be used in writing additional narratives.

DATA AND ANALYSIS

A hallmark of childhood literary works is most certainly Alice in Wonderland by Lewis Carroll. Perplexed by Wonderland, Alice was faced with many riddles during her adventures. Although the riddles piqued her curiosity, they were also a source of frustration.

The Hatter opened his eyes very wide on hearing this; but all he said was, "Why is a raven like a writing-desk?"...
"Have you guessed the riddle yet?" the Hatter said, turning to Alice again.
"No, I give it up," Alice replied. "What's the answer?"
"I haven't the slightest idea," said the Hatter. (Caroll, 1865)

Data analysis often requires the author to take seemingly unrelated sources of information and weave them together into a coherent pattern. At first, the answers may escape us, but with further introspection we can begin to see similarities between our data 'ravens' and 'writing desks'.

Some of the most compelling pieces of writing in Alice in Wonderland are the stanzas at the beginning of chapter one. The stanzas encompass the themes later developed in the story. When one re-reads the stanzas after completing the story, subtle nuances become more apparent.

Alas, a narrative story take?
Did they understand
The tale with knowledge entwined
In Memory's mystic band,
Like an August daisy chain,
…Connected, every strand

Quantitative and qualitative analysis was performed to determine the effect of the narratives on content retention. Students were administered a chapter exam after each content section in the textbook. Some of the key learning outcomes were addressed by my treatment (the narratives), while other learning outcomes were addressed by traditional teaching methods (direct instruction, individual practice assignments, labs, activities, videos and text questions). For each exam, I created a master spreadsheet of every student's response for each question multiple choice question. The students were divided into 3 main cohorts (high, average and low achievers) based on their overall

performance in the Biology 30 Course; this mark is a blended grade (50% of grade is from a semester of teacher assessments and 50% of the grade is from the provincial diploma exam). Students achieving over 80% as a blended grade in Biology 30 were classified as “high achievers”, 60-79% were classified as “average achievers” and students below 60% were classified as “low achievers”. Chapter exams were analyzed to determine which questions were covered using the narrative treatment and which questions were covered using other teaching methods. Averages were calculated for narrative vs. non-narrative questions for each of the three cohorts.

Additionally, a whole class average was calculated to show the differences between the treatment and standard teaching techniques. The multiple choice questions on the chapter exams are questions from previous diploma exams. Each question has been field tested and statistically evaluated before they were released. While there is some degree of variability in the level of difficulty of these questions, the vast majority of all questions used by Alberta Education on Diploma exams are designed to have between 55-70% of students key the correct response (Mitchell, 2011). Students who were not present for either the narrative or the chapter exam did not have their results for specific chapter tests included in their results. The number of students for all chapter exams and narratives varied from 15-18 students.

A summative standardized exam was administered by the provincial department of education at the end of June 2011. A statistical analysis is done by the province and given to the teacher which includes the class mean on each question item and the mean score for the rest of the students in the province who wrote the exam. From the exam blueprint I determined which questions were addressed by the narratives and which

questions were addressed by traditional teaching methods. The results released by the government only show the statistics of the entire class versus the province. Teachers do not received the responses keyed by each student, only whole class statistics so analysis of the three established cohorts of high, average and low achievers was not possible with this instrument.

The data for both chapter test performance and diploma exam performance was compiled in Table 5.

Table 5
Quantitative Comparison of Exam Performance for Narrative-Based Instruction and Traditional Instruction (N=15-18)

Cohorts	Mean chapter test exam performance- traditional methods	Mean chapter test exam performance- narrative methods	Differences in mean performance between traditional methods and narrative methods	Mean Diploma exam performance- traditional methods	Mean Diploma exam performance- narrative methods	Differences in mean performance between traditional methods and narrative methods
High Achievers	82.1%	83.3%	1.2%	65.3%	71.8%	6.5%
Average Achievers	66.8%	77.8%	10.9%			
Low Achievers	52.4%	66.0%	13.6%			
Whole Group	65.7%	75.2%	9.5%			

Numerous statistical parameters were used to calculate and interpret the quantitative data in table two. The chapter test data was collected for 8 exams, with 15-18 students contributing data for each test. If students were absent for a particular narrative or exam,

only the questions they were present for were analyzed with the total number of questions adjusted when calculating individual performance.

Although most statistical tests stipulate a large sample size that is greater than 30, these tests can be performed with the knowledge that there will be a greater degree of variability using the smaller sample size. Differences between chapter test narrative questions vs. traditional instruction questions were analyzed. Using the 1.5 Interquartile Range (IQR) analysis it was determined there were no outliers in this data set. No points were less than Q_1-1.5IQR and no points were greater than Q_3 +1.5IQR, where IQR equals $Q_3 - Q_1$; Q_1 is the 25^{th} percentile and Q_3 is the 75^{th} percentile. Graphic representations also suggest the distribution of the data was not strongly skewed so a significance test could be performed. A two-sample t-test was performed with $t(842)=5.31$, $p<0.05$. I am over 95% confident the difference in values was not due to chance. An underlying assumption in this data analysis is that the data is a simple random sample (SRS) of all students taking Biology 30, in Alberta, in semester two of 2011.

This assumption must also be applied in the analysis of chapter tests when comparing the difference in exam performance for questions addressed by narratives versus questions addressed by traditional teaching methods. This data set is approximately normal; a slight skew was present, but overall the distribution was close enough to normal to perform a significance test and determine a confidence interval. A 95% confidence interval was used (M=9.5%, 95%CI[6.2%,13.5%]). I am 95% confident that the true mean difference in chapter exam performance for narrative questions vs. questions addressed by traditional instruction is between 6.2% and 13.5%. Another assumption that must be made is that question difficulty is approximately equal between

questions addressed by narrative instruction and traditional instruction. The questions used for the exams were norm referenced and field tested for reliability by Alberta Education. Additionally, the level of difficulty for most questions is fairly consistent. This limitation on question difficulty variability provides some reasonable evidence that the question difficulty for questions addressed by both narratives and traditional teaching strategies is at least similar.

Provincial Diploma exam results were analyzed for all students. Student performance on questions addressed by the narratives was compared to questions addressed by traditional methods. The mean difference between the GCCHS Biology 30 class and the provincial mean for narrative questions is slightly left skewed, meaning that there were more questions where the difference in performance was small and fewer questions where the difference was large. This data set is still approximately normal, which satisfies the conditions for calculating a confidence interval. A two sample t-test was performed ($t(12)=2.09, p<0.05$) and a confidence interval was determined to be (M=6.5%, 95%CI [0.8%,13.3%]). I am 95% confident that the average difference in student performance (GCCHS vs. province for narrative questions)–(GCCHS vs. province for questions addressed by traditional techniques) is between 0.8% and 13.3%. This larger interval is a consequence of having a small sample size. This data shows a positive correlation for exam questions addressed by the narratives, but the extent of the influence of the narratives at the 95% confidence level cannot be pinpointed to a high degree of accuracy.

To measure student retention of course material covered by narratives or traditional teaching techniques a number of quantitative and qualitative instruments were

used. The mean whole group increase in performance on questions addressed by narratives and questions addressed by traditional teaching techniques is fairly similar between the teacher made chapter tests and the diploma exam. This finding is not surprising as old diploma exam questions were used for the chapter tests.

Qualitative data from interviews and student comments on surveys were also analyzed. In comments, one high achieving student noted that the narratives "sometimes helped, other times were a distraction." This particular student expressed to the teacher in an off-hand comment that they felt they could move through the course material more quickly on their own rather than using the narrative. This finding is supported by additional survey data where high achieving students showed a stronger preference for individual study techniques and learning from the textbook than average and low achievers. Student ratings were analyzed from question three in the survey (Appendix B) and scored as "Really helped= 3", "Sort of helped=2", "Didn't really help=1" and "Useless=0" for each student. All three administrations of this survey were analyzed as a whole. The students' rating of the narratives was analyzed as a fraction of all other points awarded to the other learning instruments on the survey. This analysis provides insight into the question: How did the students perceive the effectiveness of the narratives in comparison to other instructional instruments? This data was divided into the three cohorts of high, average and low achieving students and compared to the influence of narratives on their actual exam performance (Figure 2). Student perception was measured by determining the points awarded for narratives as a fraction of the total point given for all other instruments. The effect of narratives on exam performance was

measured by subtracting the non-narrative mean score from the narrative mean score. Figure 2 compares these two values for each student.

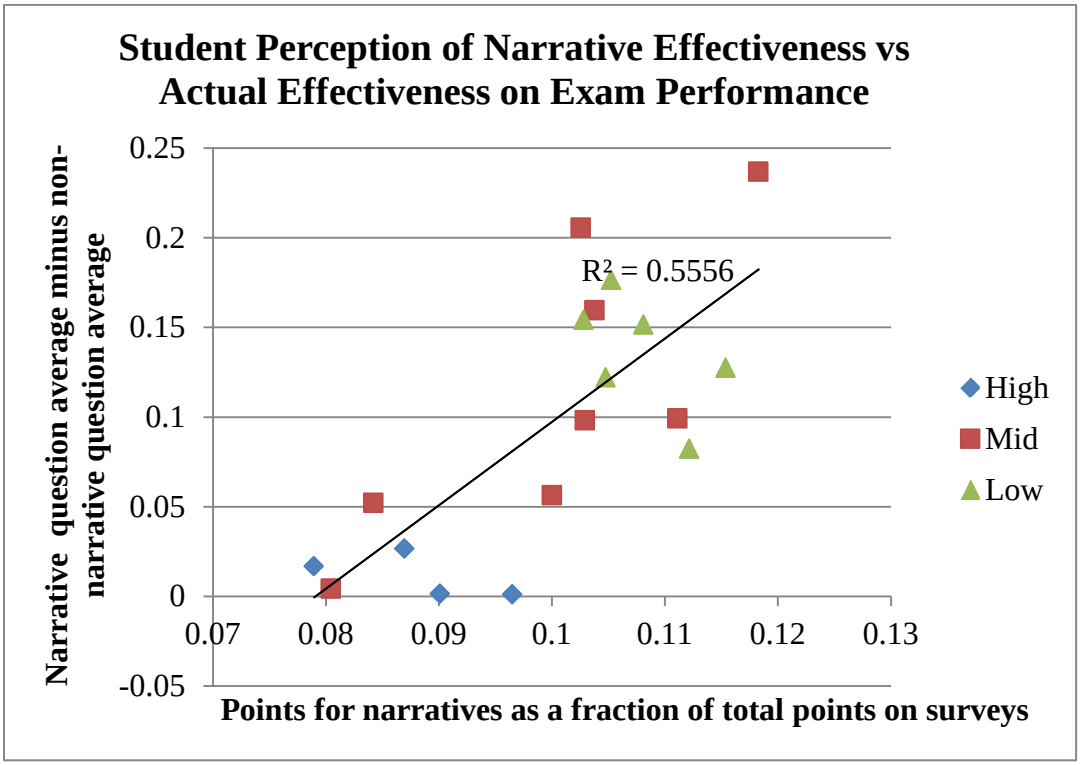

Figure 2. A comparison of student perception of narrative effectiveness to actual effectiveness as measured by chapter test performance, (*n*=18).

The results show that there is a moderate correlation between student perception of narrative effectiveness and actual effectiveness on exam performance, R^2=0.56. The high achieving cohort, who saw a negligible increase in exam performance, rated the effectiveness of the narratives comparatively lower than the low achieving student cohort who showed the greatest gains from narrative instruction.

The previous data analysis compared student ratings for narratives against all other instructional techniques which included different forms of communication (direct

instruction, videos, textbook etc.). An analysis of the same survey data (Appendix B) was performed to compare the narrative stories against the mainly expository textbook.

Table 6
Teaching Instrument Effectiveness for Narratives and Expository Text Score as Rated by Students on a Survey Instrument (N=9-17)

	Narrative (*n*=12-17)	Text (*n*=9-15)	Difference
High Achievers	74	59	15
Average Achievers	82	43	39
Low Achievers	98	53	45

Note. N is the number of student comments.

All cohorts indicated the narratives were more effective than the textbook, but the perceived difference was much greater for average and low achievers than high achievers. In the survey comments, some high achieving students noted that the textbook helped “build a base” and “answer homework questions because it gave you detail”, while others noted the textbook was “confusing”, “very wordy” and “hard to sort through”. The comments from the low achievers seemed much more critical referring to the text as “extremely boring”, “difficult to understand” and an all-encompassing evaluation, “it sucked!”. Only 7% of comments from the low achieving students evaluated the textbook positively, compared to 14% of comments from average and high achieving students.

In small group interviews (Appendix D) students were asked about the impact of the narratives on their learning.

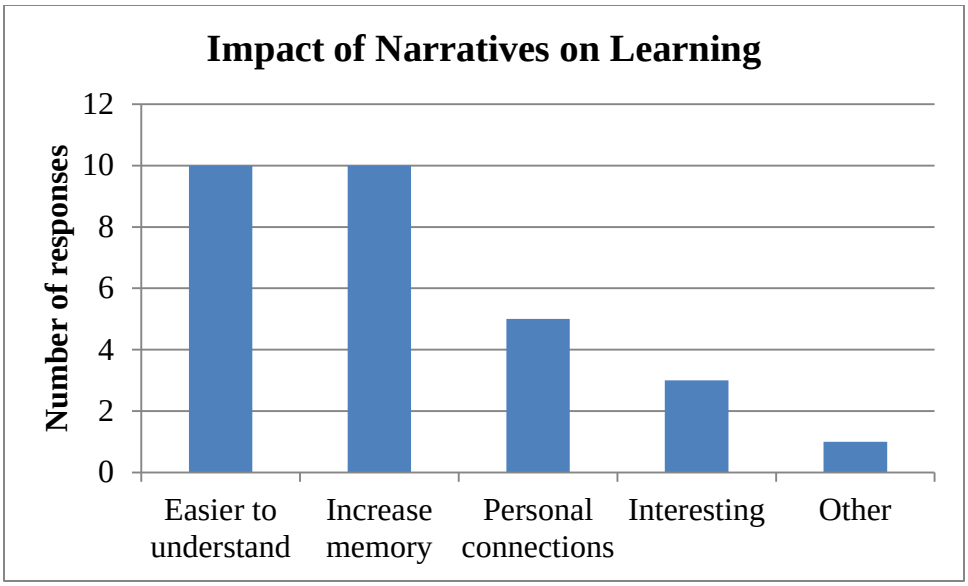

Figure 3. Students' evaluation of the impact of narratives on their learning as determined by small group interviews, (*n*=18). *Note.* The surveys were conducted using six small group interviews with three students in each group at two different times during the year.

The categories "Easier to Understand" and "Increase Memory" are the most directly related to determining the effects of narratives on content retention. These two categories also had the highest frequency of responses. This finding, along with the survey data analysis in Figure 6 suggests that students' perceptions of the effectiveness of the narratives were accurate when compared to their exam performance. Comments from the interviews included the narratives made it "easier on the test because you could think about it in different terms" and "painted a picture in your mind so you could remember something specific...". These comments are thematically similar to written comments on the survey where students stated that narratives "helped solidify the topic" and "helped the info stick". On the Classroom Assessment Data sheet (Appendix C) students identified that the novel and strange subject matter made it much easier for them to recall than other information in the course.

Analysis of teacher made chapter exams, provincial diploma exam, survey ratings and comments as well as small group interview comments reveals the students believed the narratives were effective at enhancing their learning and this effect was quantitatively reflected in increased exam performance for both teacher made exams and the summative diploma exam. It is important to note that the effectiveness of the narratives was not the same for all cohorts; high achievers did not significantly benefit from the narratives where average and low achievers had significant gains.

The second research question sought to determine the effect of the narratives on student interest in Biology 30. The major instruments that were analyzed were survey comments, small group interviews and video analysis. In the small group interviews, students were asked to identify what they liked and disliked about the narratives; this information is summarized in Figure 4

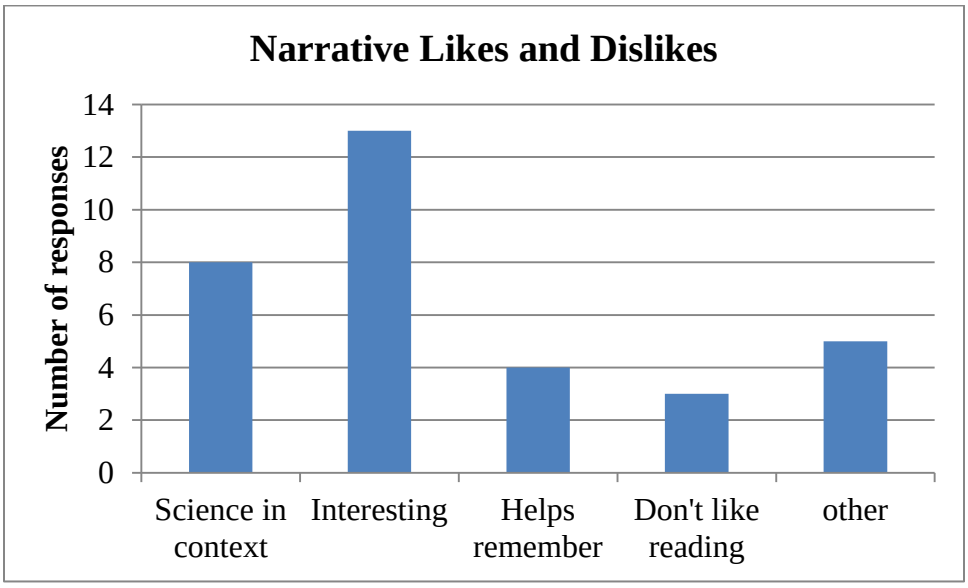

Figure 4. Students' small group interview responses, (*n*=18).

Many students identified a relationship between interest and learning that takes place in context. The narratives were referred to as interesting because they "related it [content] to actual people that experienced it". One student remarked that the narratives were "interesting, offered more perspective and [made] me want to learn more".

A quantitative analysis of student comments taken from the survey (Appendix B) compared student comments regarding the narratives to student comments regarding the textbook used in the course (Figure 5).

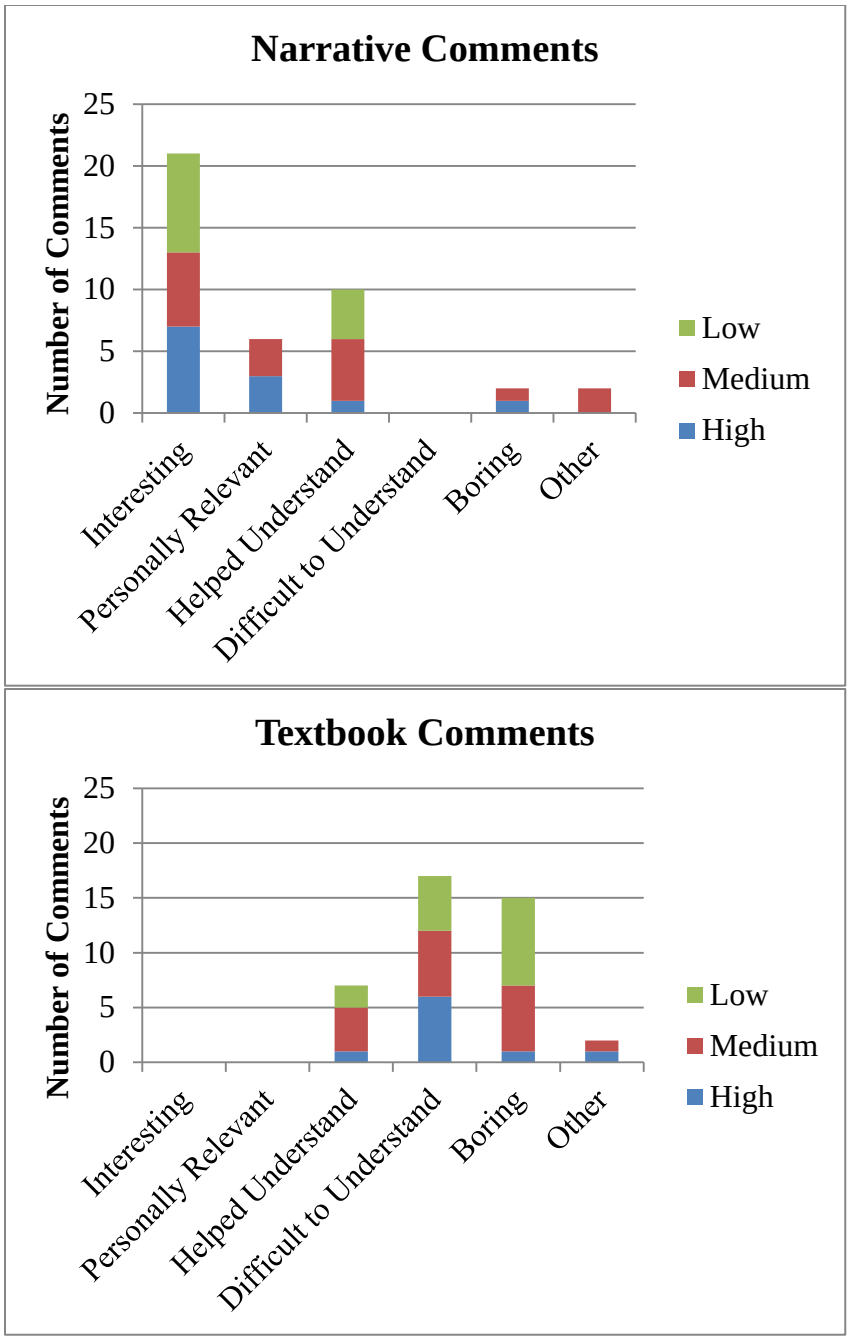

Figure 5. Quantitative analysis of student survey comments examined by achievement cohort, (*n*=18).

From this comparison many interesting findings emerge; the narratives were more interesting, personally relevant and helped students with understanding content more than the textbook based on survey comments. Interestingly, no low achieving students stated

narratives were boring although some high and average achieving students felt this was the case. All cohorts identified the textbook as difficult to understand. This data may suggest reading difficulty has less of an effect on interest for average and high achieving students than low achieving students.

Student interest was also measured as a function of student engagement in a lesson with the underlying assumption being that if a student is more interested in a topic they are more likely to participate in the lesson. Lessons were recorded and the amount of time the teacher and the students spent talking was compared for all eight narratives for lessons that used narratives and other instructional techniques (Figure 6). This calculation was expressed as a percentage of total lesson time to take into account differing lesson lengths.

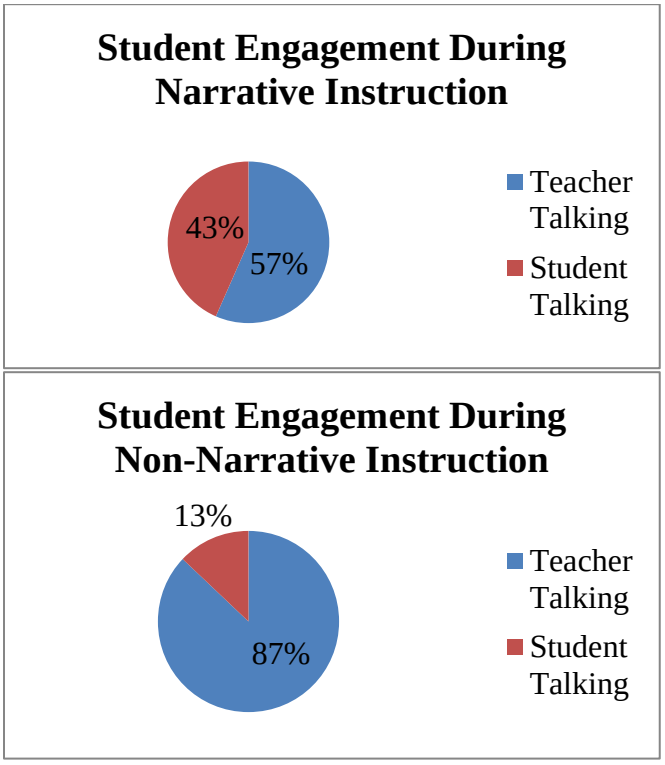

Figure 6. Student engagement during narrative and non-narrative instruction as a proportion of total lesson time spent speaking, (*n*=8).

Figure 6 indicates considerable more student engagement during narrative instruction than non-narrative instruction. This increase in engagement may be due to narratives activating the students' prior knowledge and personal experience. In Figures 3 and 4 a large number of comments indicated that students liked narratives because it presented science in context. Students may be more willing to participate in a lesson where they share personal views because such comments are more subjective in nature and there is no 'wrong answer'.

A measure of how many individual students were interested in the lesson was tabulated by the comparison of the number of different students asking questions during narrative and non-narrative instruction for a particular topic (Figure 7). Because both video segments pertained to the same subject matter, validity was increased; there is greater likelihood that student engagement is affected by the format of the content (narrative vs. non-narrative instruction) than by subject matter itself.

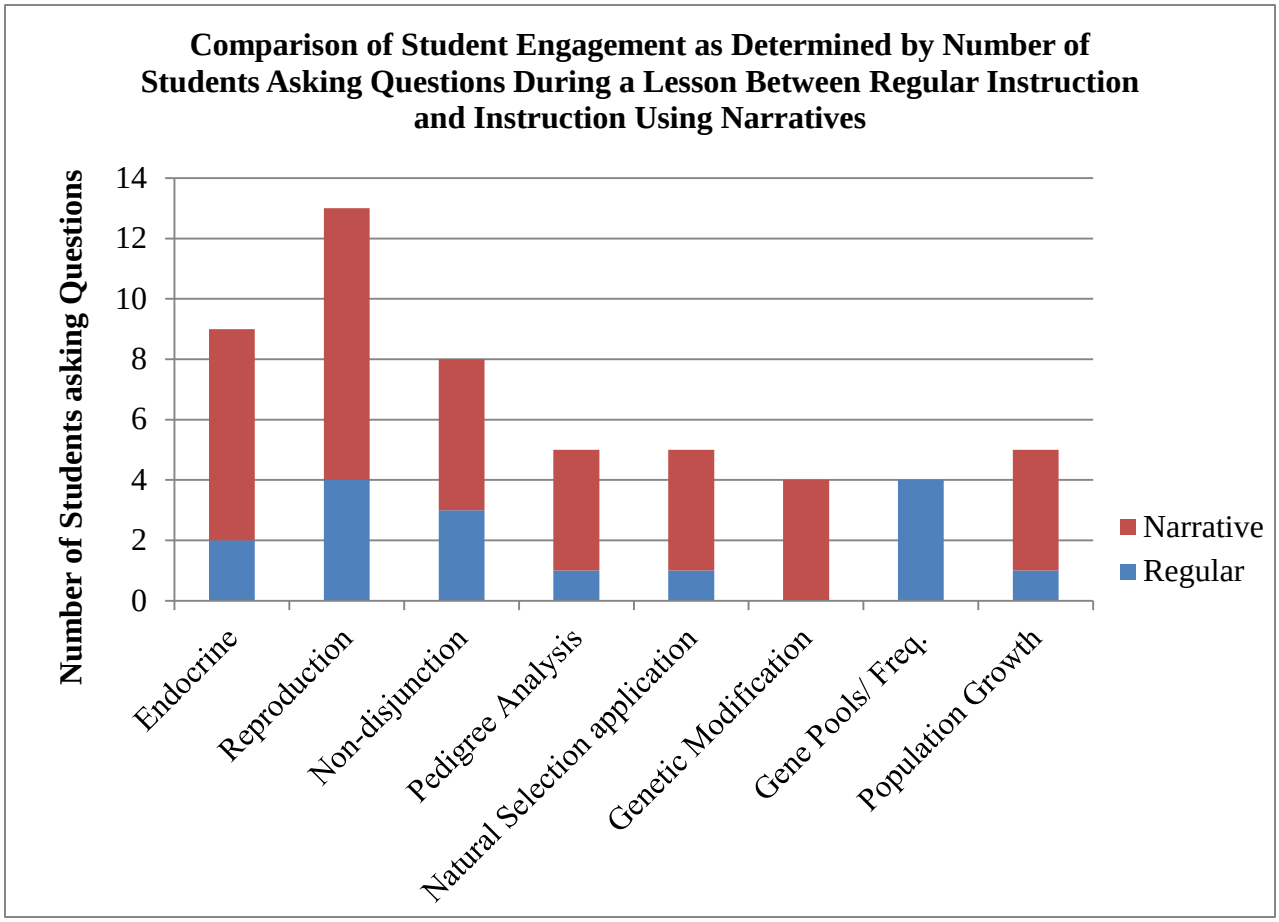

Figure 7. Student engagement during narrative and regular non-narrative instruction as determined by the number of different students asking questions during a lesson, (*N*=8). *Note. N* refers to the number of narrative cycles studied.

With the exception of the narrative lesson on gene pools, narrative instruction generally yielded a greater degree of interaction from a broader cross-section of the class than traditional teaching methods. One student commented in a small group interview. that the narratives "… make it more interesting than the lecture". Another comment, "bio actually matters outside the classroom", revealed that interest in subject matter may be strongly linked to the applicability of the content in the student's life. Quantitative analysis of interview comments suggested that narratives had a positive effect on students overall interest in the course (Figure 8).

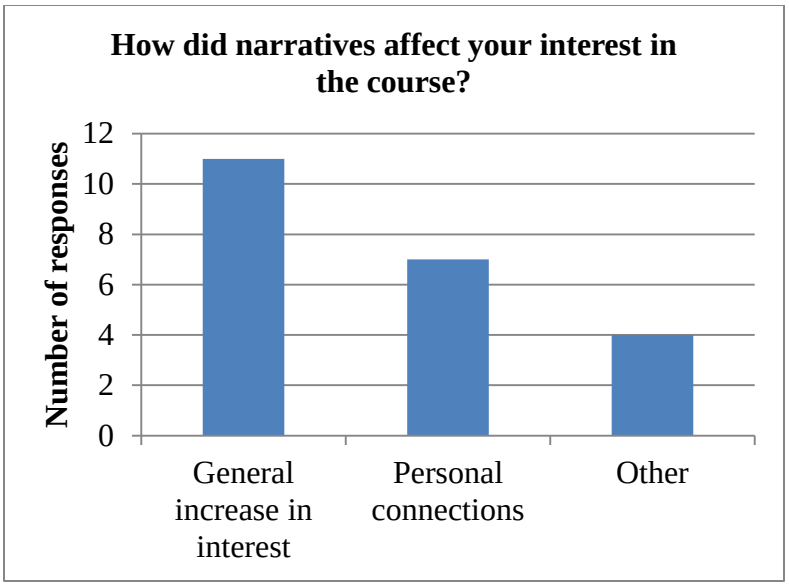

Figure 8. Effect of narratives on student interest in Biology 30 Course, (*n*=18).

Research suggests that students tend to excel in subject matter that they find interesting and relevant (Alberts, 2010). In this study there may be a possible link between student interest and retention. This relationship may help provide some justification for the markedly larger gains for average and lower achieving students on content addressed by the narratives. In the survey data (Appendix B, Question 1) many of the high achieving students also indicated a high interest in biology; one high achieving student commented "I really enjoy Bio and it influenced my choice of study in university next year." This comment could suggest that one reason why high achievers do not see significant gains in retention from narrative instruction is that they are already inherently interested in the biology content while the low achieving students indicated that some traditional learning techniques, such as reading from the textbook bored them and they had a difficult time paying attention.

The final research question of this study examined the effect of narratives on teacher instruction. Many instruments already discussed were used in addition to a

teacher field notes (Appendix E) and reflective log (Appendix F), CAT data collection (Appendix C), narrative ranking (Appendix G) and classification of narratives (Appendix H). Field notes provided an account of what happened during the lesson and this record was purely observational, while the teacher reflective log was the editorialized version that also evaluated the lesson. After each narrative, three things that went well during the lesson were recorded, the reasons why it went well and the challenges of the lesson. The qualitative results were thematically organized and converted into quantitative data (Figure 9).

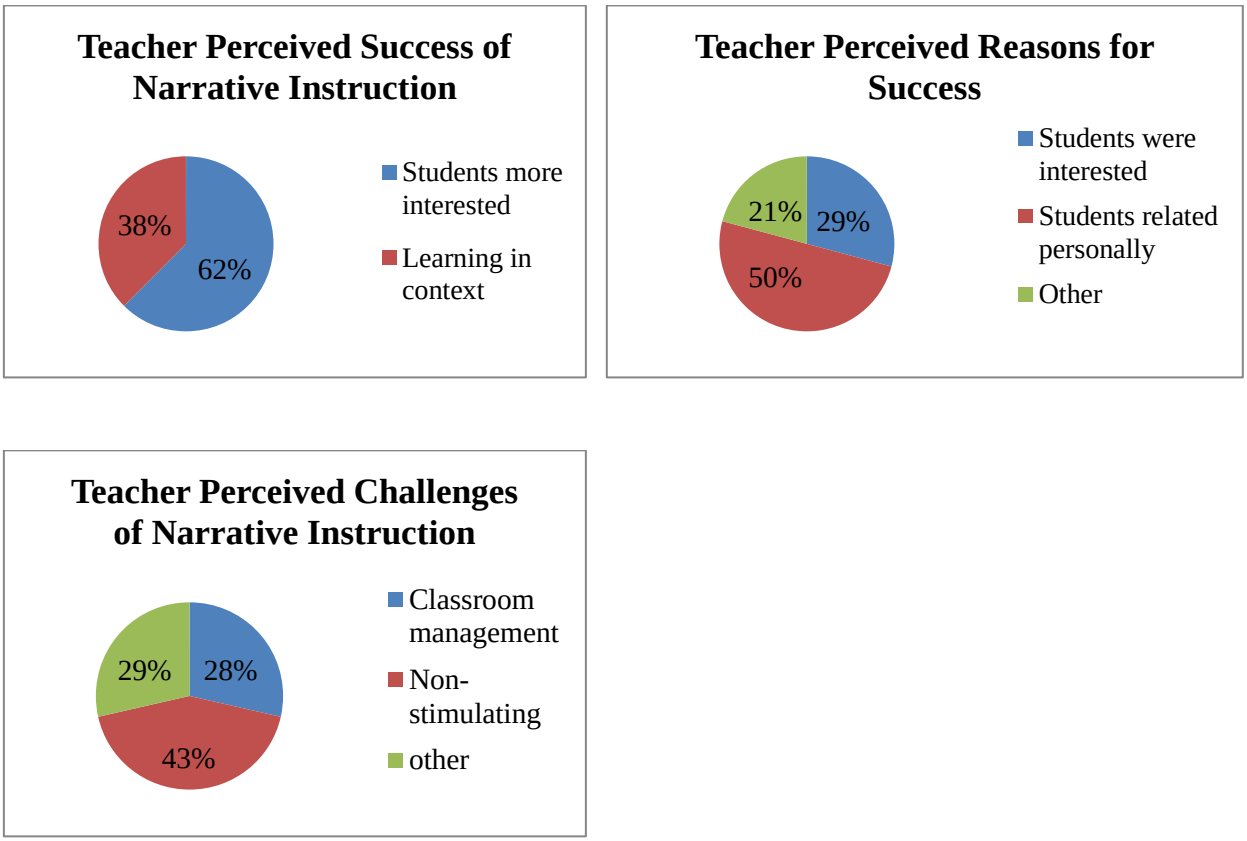

Figure 9. Effect of narratives on teacher instruction as measured by a teacher reflective log, (*n*=8).

The thematic analysis indicated the teacher's perception of the effect of narratives on interest closely aligned with the students' perception as indicated in Figures 4-8. The

application of content to personal or historical contexts was a strength indicated by the teacher and the students. In regards to the "Freak Show" narrative (Appendix A) a student commented in the small group interviews "you can see someone with a hairy face and say- 'whoa- hormones'"; this comment displayed enthusiasm for learning science in context.

The major challenges for implementing narrative instruction were that this more open lesson format often created classroom management challenges and students were not always interested in the aspects of the narrative deemed important by the teacher (43% non-stimulating). The latter challenge could be addressed by developing better strategies for eliciting and extending student responses to the narratives.

A sub-question that naturally evolved over the course of the study was: What narrative characteristics have the strongest influence on exam performance? The eight narratives were ranked from 1-8 for various characteristics and these results were compared to the exam performance (Figure10). As previously mentioned, exam performance was determined by comparing question performance on content addressed by narratives to content addressed by other teaching techniques. Reading level was calculated using the Flesch-Kincaid Grade Level Score criteria and is a function that can be performed by Microsoft Word. Narrativity was evaluated by science and/ or literacy specialists using the Classification of Narratives Instrument (Appendix H). The eight narratives were placed on the spectrum by the respondents and values were assigned; 1 was assigned to the most expository narrative and 8 was assigned to the narrative with the highest degree of narrativity. Student interest and was evaluated using the Narrative Ranking Instrument (Appendix G); ratings were compiled from all student instruments

and a rank was established. Content connections refers to the students' evaluation of how closely each narrative aligned with the Biology 30 curriculum and were determined using the Narrative Ranking Instrument (Appendix G). The number of questions asked as derived from the video analysis functions to show the level of interest in each narrative. Student engagement was evaluated on the basis of the video analysis that compared the percent of the lesson students were talking as a proportion of the total lesson time. For each characteristic an R-value was calculated and appears in brackets behind the heading. The predicted test score change compares student exam performance on the lowest ranked narrative to the highest ranked narrative for each characteristic.

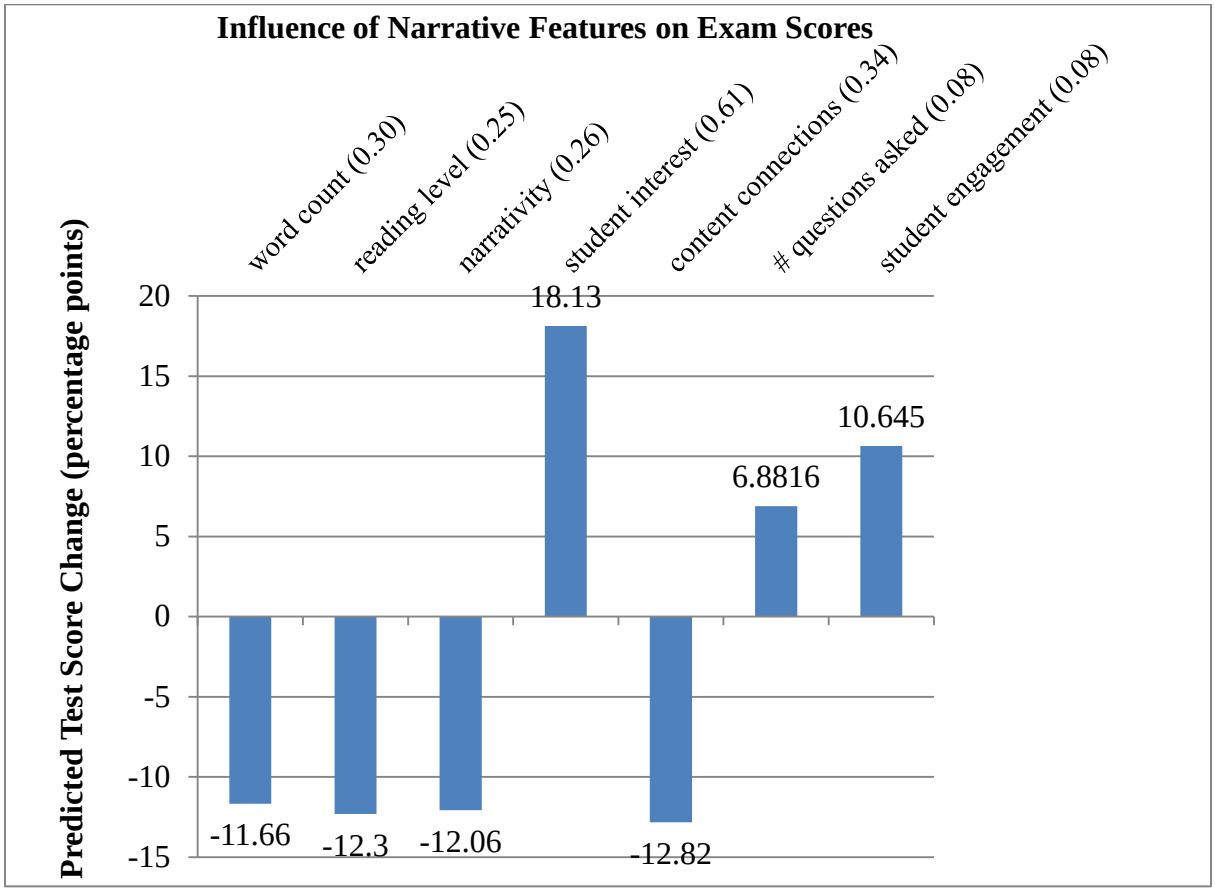

Figure 10. Comparison of narrative characteristics to exam performance. *Note.* (*n*=8) for word count, reading level, # of questions asked and student engagement; (*n*=18) for student interest, content connections; (*n*=36) for narrativity ratings.

The graph indicates a positive correlation between student interest and exam performance; it was determined an 18 percentage point difference between the lowest ranked narrative and the highest ranked narrative. A relatively high R-value suggests there is moderate robustness to this correlation. The "# of questions asked" and "student engagement" are also indicators of student interest; while both of these characteristics showed a positive correlation with exam performance, the R-values are so low that these results were deemed insignificant.

Reading level and word count showed a negative correlation with exam performance. When one considers the cohorts who benefitted the most from narrative instruction on their exams (average and low achieving students) it is not surprising that as reading level and narrative length increased exam performance decreased, as these cohorts typically have the weakest reading strategies.

A surprising result was the fact that there was a negative correlation between narrativity and exam performance. While the R-value does not indicate a strong correlation, this result is still somewhat significant. This result may suggest that there is an optimum level of narrativity; a level that is perceived as enjoyable by the reader, but still cues the reader to memorize and retain important facts. The content objectives may have been obscured by the more fictional writing style of the narratives. It is important to consider that all the narrative short stories would likely be categorized towards the 'narrative' end of an expository –narrative spectrum on the Classification of Narratives Instrument; the most expository of the Biology 30 science narratives would likely still be considered to have a greater degree of narrativity than the course textbook. There may be

a narrativity threshold, beyond which the writing style begins to hinder student performance.

'Content connections' had a moderate R-value and showed a negative correlation with exam performance. A possible explanation could be that the narratives that seemed to have a stronger connection to the content also covered topics more foreign to the students.

From this analysis some generalizations can be made with a moderate degree of confidence; narratives should be short in length, with as low of a reading level as possible, not let narrative writing conventions obscure factual content and be interesting to the students. This information will be highly useful to me in the future as I continue to write and evaluate more narratives.

INTERPRETATION AND CONCLUSION

Using narratives in science can be challenging due to the high content demands and limited time frame of the course. The most common challenges of implementing the narratives was classroom management issues (28%) and students failing to value the same aspects of the narratives as the teacher (disinterested 43%) (Figure 9). For effective implementation of narratives the teacher needs to be aware that their frame of reference is going to be different than the students, but it is sometimes necessary for the teacher to focus students on salient aspects of the narratives to promote depth of understanding for the content the narrative is addressing.

Perhaps the most significant research was the identification of narrative characteristics that positively influenced exam scores. While some of these results were intuitive, simple reading level and short lengths promote learning, the negative correlation between narrativity and exam scores was unexpected (Figure 10). This result may be due to the fact that respondents had a difficult time rating with their classification. The mean standard deviation for the narratives 1.74 which is very significant when one considers the rating scale of 1-8. The "Freak Show", "Goat Gland Doctor" and "Collapse" narratives had the highest standard deviations, 2.4, 1.9 and 1.9 respectively. Interestingly, "Collapse" and the "Freak Show" narratives had the greatest effect on exam performance compared to the other narratives (Figure 11).

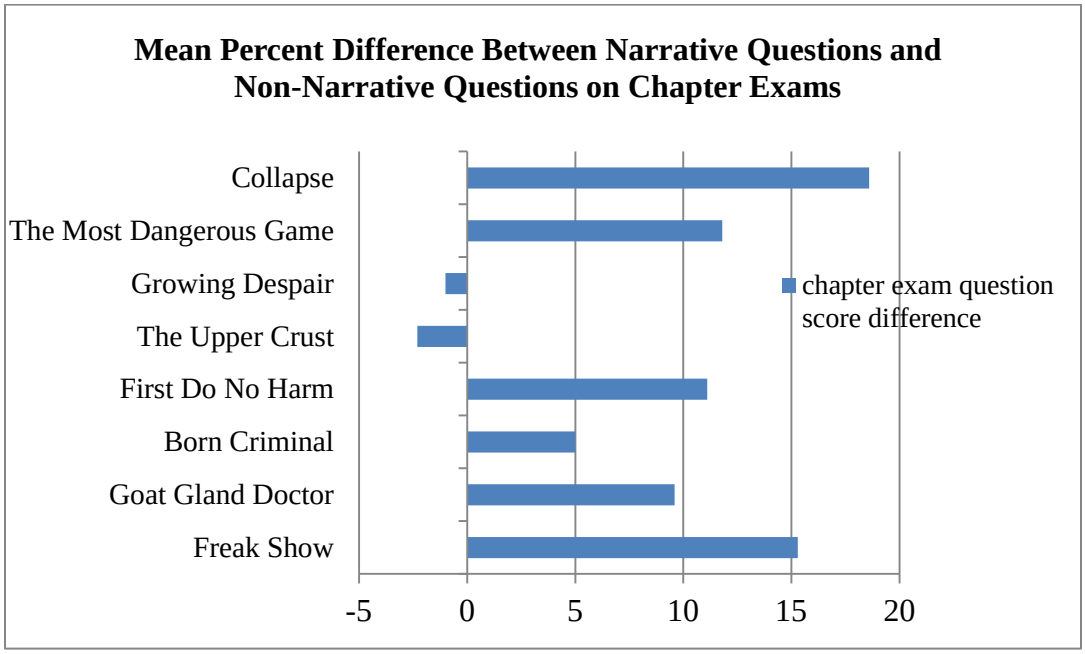

Figure 11. Comparison of mean percent difference between narrative questions and non-narrative questions on chapter exams for eight narratives used in the study, (*n*=15-18 for each chapter exam).

This finding raises the question: Why were the narratives that were the most effective at increasing exam performance, the most difficult ones for teachers to classify?

Perhaps some modifications could be made to the Classification of Narratives Instrument (Appendix H). One modification could be to use example excerpts for expository text and narrative text on the spectrum to get a clearer picture of where the narratives rank in absolute terms instead of the relative comparison to each other. In place of ranks, ratings may be used to make it easier for respondents to evaluate the narratives. While modification of this instrument would certainly affect results, my hypothesis is that there is a 'narrativity threshold' where cues for content may be obscured by the narrative writing style. The student's brain may switch from reading analytically to reading for pure enjoyment, ultimately negatively affecting memory. If this hypothesis is true, it may be deduced that the best science narrative may have elements of both the expository and narrative style.

After the examination of the effects of narratives on student retention of content, some conclusions were drawn. The results of the chapter test analysis, where the three cohorts of high, average and low achieving students could be defined, narratives had a significant learning impact on average and low achieving students; exam performance was 10.9% and 13.6% higher, respectively, for questions addressed by narrative instruction. Due to the marginal increase in exam performance for high achievers, 1.2%, we must assume the null hypothesis. A possible reason for this result could be that the high achieving students have effective literacy strategies already in place for interpreting a wide variety of texts. High achieving students would have larger vocabularies and would likely be more attuned to the subtle nuances in the precise terminology commonly found in expository texts such as the course textbook.

The use of narratives in the classroom also impacted student interest. From analysis of interview data, the most common comments were that the narratives were interesting and helped students make connections between the content and their real life experiences. The latter trend is perhaps the most significant. If students can see the science that is all around them, they are more likely to continue on a path of life-long learning. Teaching science in context underscores the value of the science content to students.

All teachers have a limited time to prepare students and are often focused on doing a thorough job of 'the meat and potatoes', neglecting any sidebar that may seem superfluous, but this study reveals that spending time on the 'dessert' may equate to significant learning gains. When students are captivated by a topic, their curiosity piqued; they have intrinsic motivation to learn more. They act as detectives to draw conclusions. This moves teaching from a 'guided tour' where the teacher is in control, to a 'personal adventure', where students direct their own learning. They may choose to take unconventional paths or back roads to learning, but it is their personal journey that is meaningful to them. Students are more likely to observe the 'learning landmarks' if they feel the destination is worthwhile.

After analyzing many different forms of data, it can be concluded that the narratives were a positive addition to the Biology 30 class. While the high achieving cohort did not see significant exam gains, the overall interest in the course was positively affected for all students.

VALUE

Upon the conclusion of this study, I realized many questions regarding narratives remain unanswered and may be the subject of future research into this area. One observation that was readily apparent was that narrativity was very difficult for both science teachers and literacy experts to evaluate. I hypothesize that narrativity may be difficult to evaluate because its parameters are difficult to define. When teacher respondents were asked why they ranked a certain narrative how they did, they offered a wide range of responses; for some the most salient part of a narrative was a storyline structure, for others it was a writing style and for others it was the subject that was covered in the narrative. An instrument that would lend itself to more quantitative analysis may yield more reliable results. The basis of the instrument could be formed from Table 1 and respondents could rate each narrative from 1-5 for elements such as purpose, events, structure, time, agency and writing style. This would be based on the assumption that each characteristic has equal value, although this may not be the case. Questions such as "is structure more important than writing style?" would need to be addressed thoroughly before a scoring mechanism was determined. This type of instrument may be much easier for respondents as rating tasks often require less sustained attention than ranking tasks. If there was greater agreement among respondents as to the narrativity of each science narrative, a different correlation with exam results may be obtained.

Another line of questioning arises from the 'narrativity threshold' hypothesis proposed earlier that stated there is a point that narrative writing conventions obscure the factual content and memory is adversely affected. I suspect that the analytical brain is

not being cued in same manner as narratives that retain some elements of expository writing. An interesting study could use magnetic resonance images of subjects reading a wide variety of narrative and expository texts. Observations could be made as to which areas of the brain are the most active and the relative level of activity of these areas could be measured. These results could then be compared to performance on memory tasks to determine if there is a correlation between the level of narrativity and the ability to recall information. This data could enable the researcher to pinpoint the 'narrativity threshold' if one exists, and this information could be used to influence the writing style of future narratives.

Research into the area of science narratives is a worthy endeavour because literacy is the cornerstone of all learning. Narratives may be used as a stepping stone for struggling readers to develop better strategies for expository texts. They may also be a tool to help struggling students increase their achievement and consequently, confidence in science subjects that are perceived as difficult.

Perhaps the greatest attribute of science narratives is their ability to incite interest and intrinsic motivation to learn. The ultimate role of any teacher is not to fill students with knowledge, but to foster an insatiable desire to learn.

In closing, I feel the essence of my study can be best summarized through literary analogy. My most loved book is *If You Give a Mouse a Cookie* by Laura Numeroff (1985). Of all the books I have ever read, this one is the single most influential book for my teaching practice.

If You Give a Mouse a Cookie

If you give a mouse a cookie, he's going to ask for a glass of milk. When you give him the milk, he'll probably ask you for a straw. When he's finished, he'll ask for a napkin. Then he will want to look in a mirror to make sure he doesn't have a milk mustache. When he looks into the mirror, he might notice his hair needs a trim. So he will probably ask for a pair of nail scissors. When he's finished giving himself a trim, he'll want a broom to sweep up. He'll start sweeping. He might get carried away and sweep every room in the house. He may even end up washing the floors as well. When he's done, he'll probably want to take a nap. You will have to fix a little box for him with a blanket and a pillow. He'll crawl in, make himself comfortable and fluff the pillow a few times. He'll probably ask you to read him a story. So you'll read him one from one of your books, and he'll ask to see the pictures. When he looks at the pictures, he'll get so excited he'll want to draw one of his own. He'll ask for paper and crayons. He'll draw a picture. When the picture is finished, he'll want to sign his name with a pen. Then he'll want to hang his picture on your refrigerator. Which means he will need…. Scotch tape. He'll hang up his drawing and stand back to look at it. Looking at the refrigerator will remind him that he's so thirsty so… he'll ask for a glass of milk. And chances are if he asks for a glass of milk, he's going to want a cookie to go with it.

After reading the story, you might think to yourself, 'what a demanding little mouse!' It is true, the mouse is insatiable. It reminds me of the day I had to cover my friend Judy's class. Judy taught kindergarten. I flew down the hallway from my domain of high school students to 'the land of the little people.' Sticky hands, single mittens and little chairs abounded. To pass some time I pulled a book from the shelf, thinking it

would take me under five minutes to read it to them…. An hour and approximately 217 questions later, we were finally done. 'Wow that was different!' I thought to myself (quite the revelation- it appears that answering 217 questions had taken its toll on my cognitive reasoning). Later, when I had disinfected my pant leg and had some time to relax I wondered how the absolute enthusiasm of 'the little people' had changed to the sometimes vacant stares of my high school students. And then it hit me… there were very few 'cookies' in high school. In the story, once the mouse gets a cookie, he initiates a string of demands, but is also inspired to be very productive. It is certainly the goal of every teacher to have students create their dreams and be proud of what they have done… to have the confidence in their abilities to sign their name in pen. Why had I not adopted this approach? Was I afraid of the student demands or the loss of control in the decision making process that comes with learning? Was I 'the keeper of the cookies', only doling out the odd crumb here and there so that we could make it through the curriculum in time and be ready for government exam? It was true. I was the keeper of the cookies. I was the 'keeper of the cookies' because I feared my students would not reach the goals I had for them. I feared I could not provide for their insatiable appetite for knowledge. It took me a while to realize that creating the appetite for knowledge is a far worthier goal than providing students with knowledge and skills. After 7 years of teaching I finally realized what I had learned in kindergarten, if you give a mouse a cookie…. he is going to want another cookie. (Numeroff, 1985)

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APPENDICES

APPENDIX A

NARRATIVES

A Boy Named Billy and the Search for the Fountain of Youth

During the early part of the 20th century very little was known about the function of hormones or their location in the human body. Few animal experiments had been done and the field of endocrinology was in a fledgling state. In 1915, Dr. John Brinkley received his medical diploma from the Eclectic Medical University of Kansas City, Missouri, and began his own practice soon after[i].

Dr. Brinkley chose to focus his attention on glandular transplants. Dr. Brinkley believed that "in all living forms the basis of all energy is sex-energy" (Flower & Brinkley p.13)[ii]. He based his theory on several observations of natural phenomena. He noted that the beauty and power of a stallion was owed to full "possession of his sexual powers" (Flower & Brinkley p. 24)[ii] and that old aged quickly advanced upon those individuals with compromised sexual anatomy from the result of disease or injury. The sex-glands were all-important and that 'their activity determines a brilliant mentality or a dull brain; a state of health, or a state of disease; beauty of form and feature and skin, or wrinkles, sallowness and ugliness" (Flower and Brinkley p.21)[ii]. Dr. Brinkley believed that if afflicted individuals were to receive glandular transplants their quality of life would be restored.

A Shortage of Available Glands

In order to test his hypothesis Dr. Brinkley needed to secure a supply of donor glands. Because the sex glands are only optimal in youth, a steady and predictable supply of human glands could not be secured. Dr. Brinkley postulated "Why not borrow what we need from the animal?"[ii] (Flower and Brinkley p. 82) Dr. Brinkley looked to the humble goat. The animal was chosen for its virility, structural similarity to humans, apparent lack of disease and the high nutrient content of goat's milk[ii]. After some trial and error the Dr. Brinkley, known as the 'Goat Gland Doctor' established that a special breed of goat, Toggenburg goats, were the most suitable donor due to their apparent lack of musky odour[ii]. The doctor soon began implanting goat testicles and ovaries into humans "as one would implant a marble into the middle of an apple" (Branyan p.32)[iii].

The Procedure-"Re-Creative Gland Operation"

Male patients were assessed through blood test and collection of seminal fluids. For suitable male candidates a small incision was made in the scrotum under local anesthetic. The goat glands had to be removed from the goat, bathed in salt water solution, warmed to human body temperature and implanted into the patient within 20 minutes of their extraction from the unfortunate ungulate(Flower & Brinkley p. 20)[ii]. Male patients often had tubal ligation to preserve the seminal fluids. Dr. Brinkley's emphasized that for rejuvenation to occur seminal fluids must be preserved (Flower & Brinkley p.65)[ii]. Female patients had goat ovaries and sometimes testicles (depending on the condition) implanted in their vaginal wall. If females were to receive female goat glands, they would bare female children, while if they received male goat glands, they would bear male children (Flower & Brinkley p.34)[ii]. Patients usually

How a Famous Surgeon Combines Old-Time Religion and New-Fangled Operations on a Strange Medico-Gospel Farm

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recovered within a week, with some reporting immediate effects from the implantation.

The Goat Gland Cure

Dr. Brinkley performed well over 600 goat gland transplants[iii]. The procedure claimed to reduce sterility, increase virility, remove impotence from old men, cure dementia and arteriosclerosis, improve body shape, cure cases of insanity within 36 hours, rid the body of influenza and sleeping sickness, restore sexual vigour, reverse senility and the aging process, improve eyesight, skin conditions, constipation and reduce the rates of divorce[ii]. Dr. Brinkley's first successful transplant into a 46 year old childless farmer resulted in the subsequent birth of a baby boy, named Billy in honour of the goat (Flower & Brinkley p.18)[ii]. Dr. Brinkley had numerous patient testimonials, with many patients claiming they felt 20 years younger. There is speculation that the procedure was even performed on two state senators.

But What about the Goats?

The male goat gland donors lived out a normal existence as livestock, but the female goats usually died from the extraction process. At the height of Dr. Brinkley's practice, approximately 50 goats per week were unwitting gland donors[iv]. At times, the demand for the glands outpaced the supply and goats were shipped from many locations across the United States and Europe.

Goat Gland Inc.

During the Great Depression, Dr. Brinkley made millions from his costly $750.00 transplant procedure fees[iv]. As a side business, he started his own radio station on which he could advertise his procedure. The doctor often diagnosed patients over the radio and sold numerous healing compounds.

The scientific community wanted to test Dr. Brinkley's methods, but he was adamant that no two operations were exactly alike. The closely guarded secret of the doctor's methods made him the sole proprietor of the lucrative goat gland business. His book, *The Goat Gland Transplantation* is very ambiguous about the exact procedure. Numerous members of the American Medical Association began to question the legitimacy of the so-called 'Goat Gland Cure'[iv]. An inquiry was conducted and it was alleged that 42 deaths had been caused by Dr. Brinkley's procedure[ii]. Eventually, his medical license was revoked and Dr. Brinkley moved his practice to Mexico, where he continued performing procedures[ii]. Although the medical community doubted the effectiveness of the goat gland procedure, numerous patients believed the glands helped them throw off the shackles of old age.

Interesting Facts:

- Many new transportation routes were made to ship the goats to the Brinkley facility.
- Dr. Brinkley wore a goatee his entire life.

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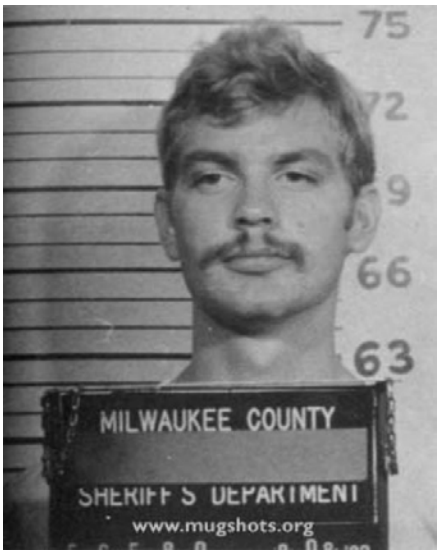


Born Criminal? The Genetic Destiny of XYY Males

The metal reinforced door slid to the side as criminal researcher Patricia Jacobs entered the Edinburgh Special Security Hospital. Her clacking heels reverberated through the hall of derelicts and deviants. The institutional glow of highly polished linoleum juxtaposed against the hardened faces of desolation made her acutely aware of her surroundings. She felt the eyes of violence tracing her path down the long expanse of hallway. Finally she arrived at the cell of her subject. He stood a menacing 6'6" tall with scars punctuating the deep fissures in his face. Her job, seemingly simple, was to take a blood sample of prisoner 437 for genetic analysis. She entered the cell and began to prepare for her sample when she felt the hot breath of prisoner 437 descend on her flushed cheeks.

"Why you visit me?" he rasped through his cigarette stained teeth.

"I am here to study you and uncover the cause of whatever drove you to commit the despicable acts for which you are incarcerated" her formality brought her a sense of relief as she reasserted their respective roles. "Now, roll up your sleeve for me, so I may take a blood sample."

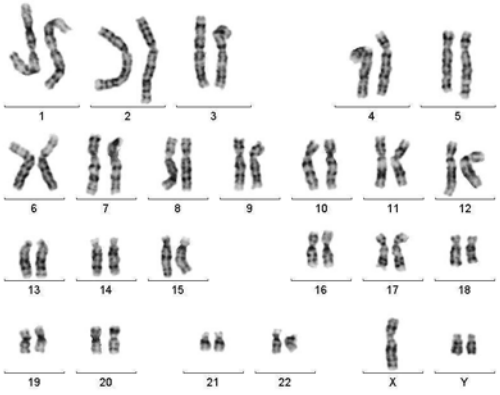
As prisoner 437 rolled up his sleeve he consciously flexed his arm bringing the sinewy muscles striations to the surface of his skin. He knew she was watching him. He looked up and the intensity of his eyes startled her as a sideways grin crept across his cracked lips. He moistened his lips with his tongue, "I'm ready."

Feeling uncomfortable she drove the needle into a pulsing vein to expedite her mission. Swirling pools of red filled the vial, as time limped forward. She removed the syringe and methodically applied a bandage. Her mechanical procedure was punctuated with compassion as her petite fingers smoothed the bandage into place. At that moment she felt empathy for prisoner 437. Perhaps biology betrayed at him at the moment of his conception; his fate to be a killer, to be a deviant, sealed by his chromosomes. Silently, she packed her kit and his sample in hand she left his cell.

After extracting the DNA of prisoner 437 and six other prisoners just like him, Patricia confirmed her initial suspicion: these men were, in essence, super males, possessing an XYY genome. Could the presence of an extra Y chromosomes account for shared attributes of heightened masculinity, exceptional height, build and predisposition towards aggression?

- The above excerpt is a fictionalized account based on real life events.

In the mid 1960's to late 1970's a number of researchers revisited a biological explanation of deviance. Most studies were based on theoretical work put forward by an Italian criminologist in the mid 1800s. Cesare Lombroso was the first criminologist to reject the commonly held belief that criminals were the product of their environment[v]. He described a theory in which a person is born criminal; he attributed the cause of deviance to be a manifestation of a human's biological destiny[i]. He believed that criminals or 'savages' were evolutionary throwbacks who were in a 'more primitive stage of evolution'[i] (p. 140) than their civilized counterparts. He believed that certain body and facial features could predict criminality. Some features included a small sloping



http://www.anana-amarok.pl/

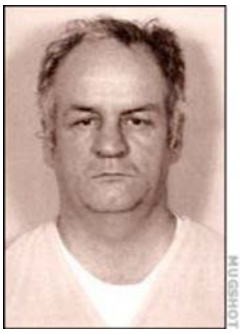
forehead, a receding hairline, large protruding ears, thin upper lip, long arms and bushy eyebrows[vi].

During Lombroso's time, very little was known about inheritance mechanisms as genetics was a fledgling field of study. By the early 1920s a chromosome mapping technique known as karyotyping could be used to diagnose chromosomal disorders. A karyotype is a photograph of human chromosomes arranged in 23 pairs. Individuals with chromosomal disorders can have one less chromosome than a full complement, or one extra chromosome. Patricia Jacobs and her colleagues karyotyped a number of prisoners at Edinburgh Hospital and discovered that XYY males were approximately 2.5x more likely to be incarcerated than males possessing the normal 46 chromosomes[vii]. Other researchers suggested a correlation between the XYY genotype and tendencies of "aggression, psychosis and schizophrenia"[i] (p.154). XYY males were posited to be 'super males' because the Y chromosome codes for male features. The XYY males were assumed to be ultra-aggressive and biological predisposed to criminal behaviour. One researcher even suggested a genetic screening program for all six year old children in the United States in an attempt to circumvent future criminal behavior[i].

Modern Interpretations of Born Criminal Theory

The XYY super male hypothesis is thought to have been greatly exaggerated[i]. While there is some correlation between incarceration rates and XYY males, it is not clear whether the incarceration is a product of biological tendencies or social prejudices held towards 'criminal body types' by law enforcement and witnesses. Many sociologists believe the media played a crucial role in exaggerating the research findings.

Find out more: http://www.scienceclarified.com/dispute/Vol-1/Are-XYY-males-more-prone-to-aggressive-behavior-than-XY-males.html



Arthur Shawcross, a famous XYY New York serial killer, killed 11 prostitutes and 2 children until his trial in 1990[iv]. He disclosed to an author that he killed prostitutes because he allegedly had a sexual encounter with a prostitute infected with HIV[iv]. He also confessed to consuming the genitals of his victims in an effort to speed up his own death (on the assumption these parts would be the most heavily infected with HIV)[iv].

[iv]Olsen, J. (1993). *The Misbegotten Son*, Delacorte Press

John Wayne Gacy an XYY male[vi] killed a total of 33 young men throughout the 1970s[v]. Gacy led a double life, running a successful contracting company and being an active volunteer in his community[v]. He belonged to the "Jolly Joker Clown Club" and performed at community events[v]. He was even recognized for his commitment to public service by First Lady Rosalynn Carter[v].

[vi]Sirkel, J., McDill, M., Tracy, C., Rybicki, S., Cosgriff, S., Fountain, M. (YEAR) John Wayne Gacy "The Killer Clown". Radford University, Radford Virginia

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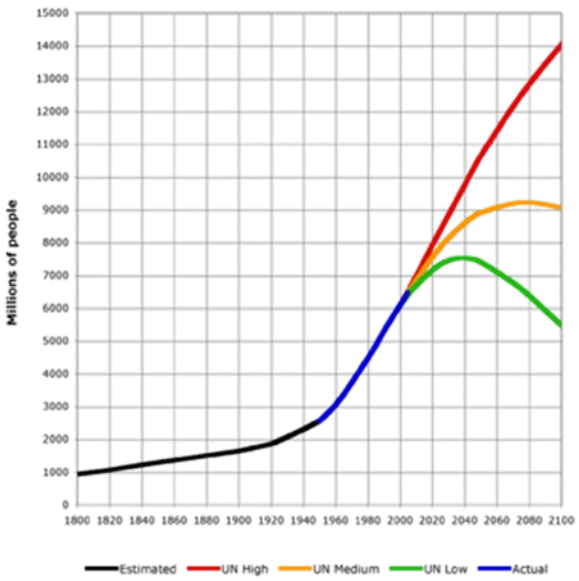
Collapse? What Does the Future Hold for Human Population Growth?

The long shadows cast by the stone monoliths on Easter Island are a grim reminder of the fragility of our human existence. The Polynesian island was colonized in 1200CE. Eventually the population grew to more than 15 000, but then rapidly declined to less than 100 individuals by the 1870s[i]. Easter Island was ravaged by disease, cannibalism, colonization and famine[viii]. Could this be a model for Earth's future?

With our many cultural constructs, advanced technology and manipulation of our natural environment, we often forget that the laws of nature also apply to humans. Humans, like any other organism are subject to the constraints of limited food supply[ix]. In 2011, the world population will reach 7 billion[x]. Thomas Malthus, one of the first scholars to discuss the potential dangers of human population growth, predicted that human population would increase exponentially until limiting factors such as disease or famine would bring the population back into check. Malthus attributed social ills such as war, famines and epidemics were due to the overexploitation of available resources. Contemporary scientists see population growth as a "multiplier of most major world problems" including environmental destruction, conflict and violence[xi]. Like Malthus, many economists and populations biologists suggest poverty is an inevitable consequence of too many people.

Agriculture, Exploitation and Medicine: A Lethal Combination?

Malthus applied population models of other organisms to humans. While natural populations have significant limiting factors to population growth such as disease, food scarcity and predation, humans have circumvented many of these factors through our technological advances. Intensive agricultural practices have raised the carrying capacity of earth. To date, survival of humans has been virtually density independent as improvements in transportation systems have allowed vast numbers of people to aggregate in small areas. Currently, there are 19 megacities with populations of 10 million or more people[iii]. There were just 3 megacities in 1975.



UN projections for global population growth.

Medical advances have cured otherwise lethal diseases and increased life expectancy. Global life expectancy is currently estimated at 65years. By 2050, it is expected to rise to 74 years[xii]. Decreased infant mortality and longer life spans are further stretching the already overtaxed resource supply.

Figure 1: Shows a possible population growth curve for humans. This "J-Shaped Curve" is usually typical of organisms that rapidly reproduce, with short life spans like bacteria. This type of growth curve could be applied to human societies such as the people of Easter Island or the Mayan. "K" represents the carrying capacity of the ecosystem.

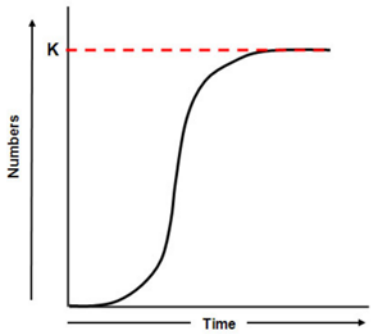


Figure 2: Shows another possible population growth curve for humans. This "S-shaped curve" is usually typical of organisms that have slow reproduction and long life spans like humans. Some scientists predict as the developing nations improve their standards of living, birth rates will decrease to the point where there is zero

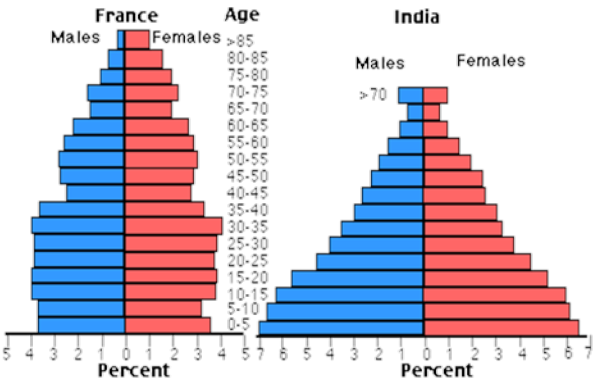
What Does the Future Hold?

"It took from the beginning of time until about 1927 to put the first 2 billion people on the planet, less than 50 years to add the next 2 billion people (by 1974) and just 25 to add the next 2 billion (by 1999)"[v]. It is estimated that another billion people will be added to the world population every 13 years [iii]. Can this trend continue indefinitely? Some scientists believe the rapid increase in population will eventually lead to the demise of our species. Hern, has likened the human race to malignant cancerous growth on the world ecosystem, a proposal called the 'ecopathology hypothesis'[xiii]. Some parallels include, rapid unrestricted growth, invasion and destruction of adjacent tissues (ecosystems), metastasis, as new areas are colonized [vi]. Does this mean the extinction of the humans? More conservative theories propose that if a global collapse does not occur, at the very least there will be a sharp reduction in quality of life. A perpetual poverty state will ensue unless population growth declines [iv].

If we continue to gnaw away at our resource supply, remove species from the web of life and permanently alter the atmosphere are we sealing our fate in the process? One day will there be only relics of our existence? …human-like rock carvings keeping watch over a vast expanse of destruction… the earth slowly reclaiming all that we have taken from it?

Fast Facts:

- Improper water sanitation kills 12 million people per year[xiv]
- By 2025, 3 billion people will face water shortages[xv]



Developed countries are currently experiencing population decline, while developing countries continue to see population increases

- Nearly 50% of the world's forests have been lost to logging, agricultural and urbanization[xvi]
- 2 out of every 3 species is in decline[xvii]
- The global fertility rate is 3 children per woman [v]
- Poorer global regions have a population growth rate more than 6 times greater than in the richest countries [v]
- In 1800, roughly 2% of people lived in cities, in 2000 more than 47% live in cities [v]
- Close to 1 billion people go hungry each day[iii]

Human Population Growth Video:
http://video.nationalgeographic.com/video/player/specials/sitewide-redesign/ngm-7billion.html

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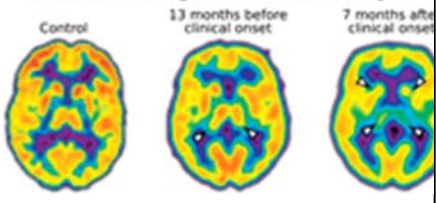
First Do No Harm… The Early Origins of Fatal Familial Insomnia

Upon graduation from medical school many physicians take the Hippocratic Oath where they promise to act justly on behalf of their patients. One of the hallmarks of the oath is that the physician must pledge to "first do no harm"; a reminder to consider the ethical consequences of their decisions to perform a medical procedure.

In a twist of genetic fate, an Italian doctor's descendants bear his legacy, a genetic disease for which there is no cure. The first documented case of fatal familial insomnia is traced back to a noted Italian physician in 1760s[xviii]. The rare disease was caused by a mutation and propagated through the generations. Fatal Familial Insomnia is a heritable disease that causes disturbed sleep patterns and progresses to complete insomnia and eventually death. Lack of sleep impairs brain functioning; afflicted individuals can develop psychosis and disturbed autonomic functions (breathing rates, pupil response and temperature regulation[xix]. Some of the early documentation of symptoms describes the diseased as having tiny pin prick pupils and perpetual sweat on their brow[ii].



PET scans of an individual affected by Fatal Familial Insomnia.

Brain (March 2006) 129 (3): 668-675. doi: 10.1093/brain/awl003 First published online: January 6, 2006

The disease is the result of a single mutated gene that causes atypical proteins called prions to accumulate in the brain, most extensively the thalamus [ii]. The prions interfere with the normal functioning proteins in the brain and can eventually lead to death of the nerves in the brain[ii]. Afflicted individuals generally did not present symptoms until the age of 30-40 years old[xx]. As the insomnia progresses, usually over the course of 7-18 months, the individual is slowly drained of their mental faculties until their eventual death.

The asylum at San Servolo as it appears today. The asylum is no longer operational and is now a museum.

http://atlasobscura.com/place/museo-del-manicomio-san-servolo-insane-asylum-museum

In the late 1700s, very little was known about how disease was born and spread. Some physicians believed the disease resembled malaria while others adhered to folklore explanations such as demon possession or witchcraft[iii].

As the generations passed, there was an increasing number of insomnia cases in the small Italian town[iii]. The branches of the family tree afflicted with FFI, became poorer and had more children to secure their livelihood, inadvertently spreading the disease with increased fervor[iii]. Due to increasing social ostracization of the family, many members immigrated to other parts of the world, taking their family legacy with them. Others were placed in an asylum on the small island of San Servolo off the coast of Venice[iii]. As their psychosis progressed, most were bound to their beds at night[i]. The only escape was death.

It was not until the 1980's, that researchers began to extensively study Fatal Familial Insomnia. Using church records, a pedigree of the disease, the carriers and afflicted descendents gave researchers some clues to the history and transmission mechanism of FFI. If one parent has the disease, there is a 50-50 chance it will be passed onto the offspring [xxi].

While the number of currently afflicted individuals is few; most estimates range from 40-200[i], the haunting progression of the disease is most remarkable. The slow descent into madness, manifesting from the elusiveness of sleep, is a legacy few of us can comprehend. It is nature's cruel irony that a doctor, a healer of many, could be the locus of a family legacy plagued by disease.

Silvano, an unfortunate descendant of the Italian doctor, offered his brain to science and much of what is known today about the disease is because of his donation.
http://sleepeducation.blogspot.com/2010/04/fatal-familial-insomnia-genetic-death.html

LEARN MORE: Video clips of Fatal Familial Insomnia

http://teachinghighschoolpsychology.blogspot.com/2010/03/man-who-never-slept-fatal-familial.html

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[xxi] Capellarila, P., Cortelli, P., Avoni, G. P., Casodei, A., Baruzzi, E., Lugaressi, M., Pocchiari, P., Gambetti, P., Montagna, P., Parchi, P. (2008). Sporadic Fatal Insomnia in a Fatal Familial Insomnia Pedigree. *Neurology*. Mar 11;70(11):884-5

Freak Show:

A Parliament of Monsters, a Consequence of Hormone Dysfunction

All moveables of wonder, from all parts,
Are here--Albinos, painted Indians, Dwarfs,
The Horse of knowledge, and the learned Pig,
The Stone-eater, the man that swallows fire,
Giants, Ventriloquists, the Invisible Girl,
The Bust that speaks and moves its goggling eyes,
The Wax-work, Clock-work, all the marvellous craft
Of modern Merlins, Wild Beasts, Puppet-shows,
All out-o'-the-way, far-fetched, perverted things,
All freaks of nature, all Promethean thoughts
Of man, his dulness, madness, and their feats
All jumbled up together, to compose
A Parliament of Monsters. Tents and Booths
Meanwhile, as if the whole were one vast mill,
Are vomiting, receiving on all sides,
Men, Women, three-years' Children, Babes in arms.

Wordsworth's description of Bartholomew Fair (from The Prelude, Book 7. 1805, lines 706 – 721)
http://www.westland.net/coneyisland/articles/freaks.htm

The living werewolf, world's ugliest woman and the smallest or tallest man were some of the main attractions during the Sideshow era from the mid-1800's to mid-1900's. Onlookers would pay admission to view individuals with deformities or conditions that rendered them more beast than man. All classes of people, including Queen Victoria I [xxii]took in the traveling spectacle of the sideshow.

Many sideshows boasted live werewolf specimens. Lionel, a famous sideshow performer was covered with downy hair on his entire face so only his eyes and lips were visible[xxiii]. Often fantastical stories were used to 'explain' the abhorrent medical condition of the afflicted werewolf. These stories often further dehumanized the sideshow performer. Today Lionel's condition would be described as 'hypertrichosis' literally meaning 'excess hair'. Hypertrichosis can be caused by genetic anomalies as well as a thyroid disorder known as hypothyroidism.

Another spectacle included The World's Ugliest Woman, Mary Ann Bevan, whose face and limbs were greatly enlarged. She was a fixture at Coney Island for thirteen years before her death in 1933[xxiv]. It was not until Mary Ann was 35 years of age that she started to exhibit some of the symptoms of acromegaly, a condition causing the excessive growth of specific body parts due to imbalances in human growth hormone[iii].

Coney Island's Dreamland exhibition also featured a "midget brigade" with the most famous performer, General Tom Thumb, who, at the age of 11, stood only 25 inches tall and weighed approximately 15 pounds[xxv]. Tom Thumb experienced very little growth in his lifetime, reaching a maximum height of 3 feet in his adult years[xxvi]. General Tom Thumb was more a performer than a museum specimen and often wore costumes and performed comedy acts[v]. His petite figure brought him great wealth and far-reaching celebrity status. Tom Thumb was even an invited guest to President Lincoln at the White House[xxvii]. His exceptionally small stature was thought to be caused by growth hormone deficiency in his early developmental years.

Sideshow performers like Lionel, Tom Thumb and Mary Ann Bevan were once dubbed 'monstrous spectacles'. An increase in medical knowledge about hormones reveals the sideshow performers' visible afflictions were merely a consequence of bad biochemistry.

[xxii] Durbach, N. (2010). *Spectacle of Deformity: Freakshows and Modern British Culture*. London: University of California Press.

[xxiii] Nickell, J. (2005*). Secrets of the Sideshows*. Lexington (KY): University Press of Kentucky.

[xxiv] Allen, G., Carlson, E., Lombardo, P., Micklos, D. (1999) Mary Ann Bevan, the world's ugliest woman. Retrieved February 22, 2011 from *Eugenics Archive*. http://www.eugenicsarchive.org/eugenics/image_header.pl?id=834&printable=1&detailed=

[xxv] Toulmin, V. (2007). Freak Shows. In *National Fairground Archive*. Retrieved February 22, 2010 from http://www.nfa.dept.shef.ac.uk/history/shows/freaks.html

[xxvi] Kriegel, L. (1969). Uncle Tom and Tiny Tim: Some Reflections on the Cripple as Negro. In American Scholar 38 (Summer 1969): 412-30, http://www.disabilitymuseum.org/lib/docs/678card.htm, Disability History Museum, www.disabilitymuseum.org (November 1, 2001).

[xxvii] Kimmel, S. (1967). *Mr. Lincoln's Washington*. South Brunswick (NJ): Coward-McCann.

Photo references:

Mary Ann Bevan:
Allen, G., Carlson, E., Lombardo, P., Micklos, D. (1999) Mary Ann Bevan, the world's ugliest woman. Retrieved February 22, 2011 from *Eugenics Archive*. http://www.eugenicsarchive.org/eugenics/image_header.pl?id=834&printable=1&detailed=

Tom Thumb:

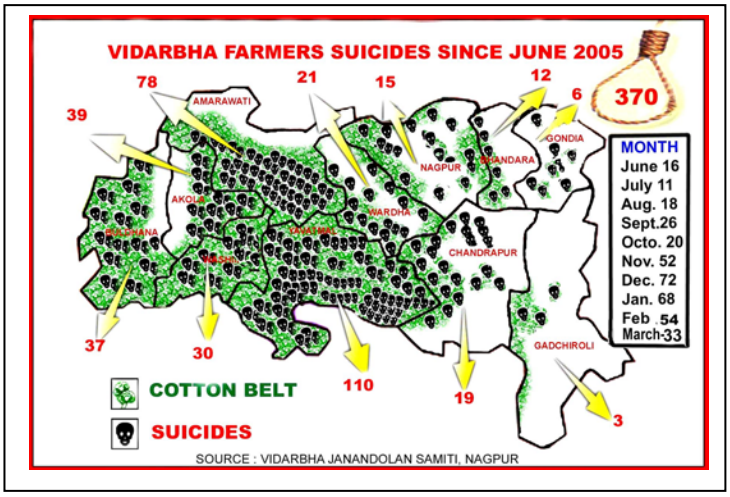
Brady, M. (1920). Tom Thumb. In *American Treasures of the Library of Congress*. Retrieved February 22, 2011 from http://www.loc.gov/exhibits/treasures/trr137.html

Lionel:
Bettman, J. (1923). Lionel Bilrouki, the Lion-Faced Man. Retrieved February 22, 2011 from http://www.corbisimages.com/Enlargement/BE044696.html

Growing Despair: GM Agriculture in India

When they found him, his body lay writhing in the sterile, dusty soil. The doctors could not reverse the deadly effects of the insecticide elixir the farmer consumed moments before. His wife sobbed as the smell of searing flesh filled the dry, Indian air; her husband's cremated corpse returned to the barren earth that broke his will to live. The land's betrayal emblazoned with the farmer's scorched remains was a grim reminder… a reminder of the debt already paid… a reminder of the debt still owing.

In the weeks after his death, the farmer's land will be seized by the lenders, leaving his family disenfranchised, burdened by death and crippled by repayments for seeds that only grew despair. This story resounds with the surviving families of an estimated 125, 000 Indian farmers who chose to take their own life after losing their land and their ability to provide for their families[xxviii]. These farmers were promised pest resistant crops with yields far beyond what they were accustomed to, if they chose to purchase genetically modified seed.



The GM seed varieties are up to 1000 times more expensive than native seed[i]. Indian farmers viewed the magic seeds as a way to end their poverty. These seeds were an investment in the future.

Monsanto took numerous steps to secure its position in Indian agriculture. Many local farmers were recruited by Monsanto to sell the seed to their neighbours[xxix]. Aggressive marketing campaigns followed by customer satisfaction surveys increased the legitimacy of GM crops in India[i]. The company has also been linked to providing financial backing for the lenders. For most farmers, their only collateral for a loan is their land. For Monsanto, its business transaction with India is quite secure; if the farms are productive, the company will establish a strong customer base and if the farms fail, Monsanto can amalgamate the land for their own purposes.

Monsanto's stronghold in India began in the 1960's when India accepted financial aid from the World Bank on the condition that it develop a more efficient food production system. Efficiency would be achieved through an increased use of irrigation,

pesticide and genetically modified crops. This movement became known as the Green Revolution[xxx]. To increase the spread of the Green Revolution, the Indian Government banned many traditional seed varieties from its seed banks[i].

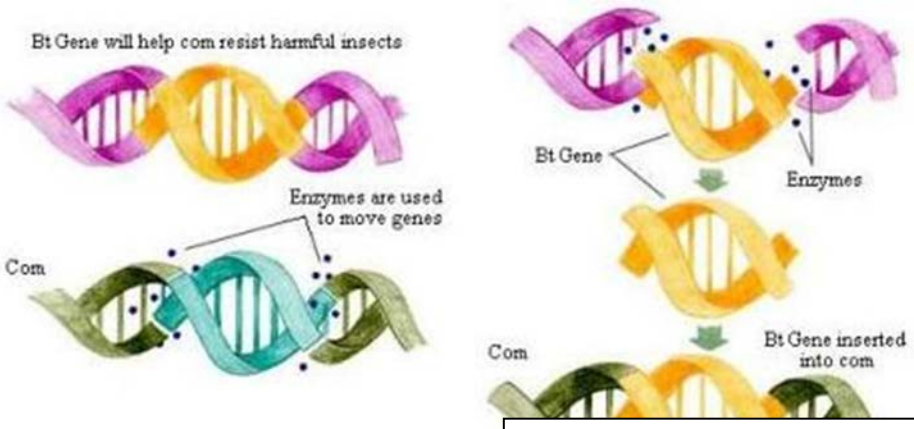
In an effort to protect the intellectual property rights for the GM seed, Monsanto bought patent rights for a technology that would prevent a plant from producing viable seeds. The 'terminator' gene, originally developed the United States Department of Agriculture, causes a mature plant to become sterile. This technology had devastating consequences for many Indian farmers. With traditional seed varieties if a drought occurred, farmers could save the seeds and replant them the following year. If the farmers bought GM seeds they would have no harvest to pay their loan and no seeds for the following growing season. The only option was to relinquish their land. For some this failure is too much to bear.

India's 'suicide belt' cuts through what used to be fertile land. Intensive agriculture, pesticide resistance and GM crops has brought devastation to the area.

How did Monsanto Genetically Modify the Crops?

Monsanto manipulated the genomes of seeds by inserting desirable genes using recombinant DNA technology. A pesticide resistance gene, extracted from the bacteria *Bacillus thuringiensis* was inserted into the seed DNA. Restriction enzymes cut out the desirable gene and cut an insertion point for the gene in the crop. The addition of this gene would mean that the crop variety would naturally produce an insecticide. They also inserted the terminator gene as well as two other control genes that would prevent the expression of the terminator gene until late in the crop's development[ii]. Other modifications included an ability to withstand exposure to a broad spectrum soil sterilizer, commercially known as 'Round-Up'. Farmers could spray their crops killing everything except their crop.

Genetic Modification Process:



http://www.xamplified.com/benefits-of-ge

http://www.mindfully.org/GE/2005/Terminator-Seeds-

Why did the GM seeds fail in India?

The seed varieties being sold to India were developed in the United States which has dramatically different growing conditions. The seeds also require two times the amount of water as traditional varieties,[I]. Farmers who could not afford irrigation systems and the seeds were not evolutionarily adapted to the climate conditions in India. In addition, many pest populations evolved pesticide resistance to the BT plants. Continuous exposure to a toxin creates evolutionary pressure on a pest population. Natural Selection will cause the frequency of individuals with natural resistance to the BT plants to increase in population. Most resistant organisms will have homozygous recessive genes and as these genes increase in frequency, the number of homozygous dominant and heterozygous individuals will decrease substantially, reducing variation in the population[xxxi].

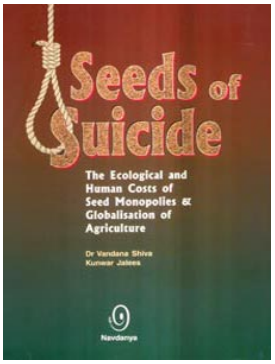
What are the Future Consequences of Using GM crops?

Many scientists warn the terminator gene could be responsible for complete collapse of all plant species world-wide. Pollen from the terminator plants could mix with wild plants, preventing reproduction. This genetic drift of the terminator gene could potentially affect all plants. Monsanto researchers say this scenario is unlikely because most plants reproduce asexually and crop species all reproduce at a single time of year where wild plants stagger their reproduction[ii]. GM crops have also been linked to colony collapse disorder, which threatens to kill many of the world's natural pollinators such as bees and wasps[xxxii]. Over 90% of all agriculture in North America uses Monsanto products. Farmers who do not use Monsanto products are often black-listed with wheat purchasers or subjected to random field tests and sued if the tests turn up any Monsanto patented varieties, even if these varieties are from cross-pollination with a neighbour's field. Many activists feel the monopolization of the world food supply in a single multi-national corporation is cause for growing concern.

Prince Charles has labelled the situation in India as the GM genocide[iii]. Many activist groups are lobbying governments to create independent seed banks and to provide financial aid to India to promote organic agricultural practices. Will this change be too late for the Indian farmers?

Find Out More:

Watch Seeds of Suicide: India's Desperate Farmers
See both sides of the debate: http://www.pbs.org/wgbh/harvest/



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[xxxii] Linked to colony collapse disorder: "ARS : Questions and Answers: Colony Collapse Disorder". *ARS News*. 2008-05-29. http://www.ars.usda.gov/News/docs.htm?docid=15572. Retrieved 2008-11-23

The Most Dangerous Game

Breathless, the anticipation flooded his veins like an army descending on the enemy. The icy metallic of the trigger was gingerly embraced. Senses sharp, his trophy lay in wait as he aligned the cross hairs of the rifle scope. Time, counted by the slow heaves of controlled breathing, could land him his prize if the elk remained unaware of its ambush or just as easily lead to a fleeting flash of rusty brown and a slowly disappearing target. It was a game of nerves. Eyes focused, steady gait, instinctual reflex sealed its fate. The majestic beast instantaneously aware of the crack of the gun had no time to react. In a moment, the sinewy muscle was pierced; its velvet perfection rippled under the force of the bullet. Wide-eyed, it ran, lurching through the forest trying to escape death. The hunter, still pulsing with adrenalin, followed the crimson trail. In a clearing the giant lay on its side with death's sickle on its neck as the light faded from its eyes. The hunter marveled in its beautiful perfection; the sprawling symmetry of its crown would be a nice adornment to the vacant space above the fireplace.

As the years passed, time gnawed at the once strong stature of the hunter. The immortal mount of the elk looked on as death slowly seized the man who took its life. When the hunter would peer at his prize, it reminded him that it was he who won the game. He would look at his preserved captive and muse that hunting is "the best sport in the world… for the hunter."[xxxiii]

When we think of hunters and their prey it is easy to conjure the thought that in the outcome of this match-up there is going to be a winner and there is going to be a loser. Sometimes the loser is the hunter as the prey evades his or her advances and sometimes the loser is the prey. Other times the prey escapes and the hunter walks home empty handed. What most of us fail to consider is the outcome of the game may change the game itself.

When hunting was an activity of survival, most of the animals chosen were extremely young or very old because they were the easiest to catch[xxxiv]. Today, hunting is often a leisure activity with the goal of killing the most prized animal. The non-random removal of certain animals based on size, behavior or morphology will alter populations if these traits are heritable[iv]. Even conservation management strategies focus on removing the alpha males from the population by setting minimum age or size guidelines. The result is a population with many females and inferior males[iii]. By removing these specimens with desirable traits, hunters are actually creating *less* of these traits in future populations.

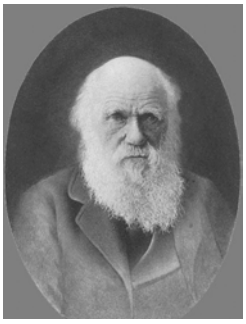
A thirty year study that examined horn length in big horn sheep from Ram Mountain, Alberta documented a 25% reduction in horn length in the total population once trophy hunting was allowed in the area[xxxv]. Genetic testing showed a decrease in the genes

responsible for large body size and long horn length and an increase in the genes that coded for delayed maturity and smaller body size. Genetic variation in the population also decreased as certain alleles were selected against by the hunters. The animals killed did not achieve the reproductive success that one could expect because mating success increases with age, dominance and horn length[xxxvi]. Allendorf and Hard call this phenomenon "unnatural selection", because weaker, smaller animals are more likely to survive and pass on their genes to the next generation when hunting is active[xxxvii].

Similar findings have been documented for European red deer, antelope, white tailed deer and the red fox[vii].

A similar pattern emerges on all continents where game hunting is practiced. Humans have undoubtedly altered the evolutionary path of elephants in Africa. The elephant population, often killed for their ivory tusks has undergone a genetic shift in which the frequency of "tuskless" elephants is increasing[iii,iv]. A tuskless elephant would have a difficult time surviving and securing mates in a natural environment. The tusks are used as defense and to battle rival males for access to females. Big game hunting has reversed the winners and losers by preventing the genes for tusks from making it to the next generation. There has been as much as a 90% increase in the number of tuskless elephants in some parts of Africa[iii]. When the tusked elephants fail to mate or sire less offspring than expected, these genes are lost from the gene pool.

Darwin, an avid hunter, did not thoroughly apply his theories regarding artificial and natural selection to hunting practices.



The genetic consequence of hunting have been identified as the alteration of the population structure, which can include altering the sex ratios of males to females as well as disrupting social hierarchies, loss of genetic variation and evolution resulting from man's purposeful selection of animals[xxxviii]. Gene flow may be reduced between populations as a disproportionate number of males are removed from the breeding population. The effects of genetic drift, the random loss of alleles from a gene pool, may have a more pronounced effect on populations that already have reduced diversity from hunting practices[vi xxxix].

Big game hunting is often the leading cause of mortality in some populations of animals, therefore it should be strongly considered as an evolutionary agent[vi]. The purposeful selection of certain animals is a "very risky game… that is highly likely to result in the end of a species."[iii]

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[xxxiv] Sforzi, A., Lovari, S. (2000). Some Effects of Hunting on Wild Mammalian Populations. Ibex J. Mt. Ecol. 5: 165-171 Anthropozoologica 31:165-171.

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The Upper Crust: Eugenics in Alberta

After endless visits to the doctor and years trying to get pregnant, Leilani Muir finally discovered the real reason she could not conceive: her one fallopian tube had been completely removed and only an inch remained of her second one[xl]. While many women have tubal ligation as a means to permanent birth control, Leilani had the procedure performed as a teenager without her knowledge.

The year was 1955. Leilani recalls her mother parking outside the Michener Centre in Red Deer, Alberta, and instructing her to meet a nurse who was waiting for her. She left at the age of ten, with only the clothes on her back, to be admitted to Alberta's Provincial Training School for Mental Defectives[i]. On the basis of a single IQ test and a short interview, the Eugenics Board approved Leilani for sexual sterilization[xli]. While in the care of the Centre, Leilani was told that her appendix would be removed, but it was during this surgery that she was sterilized[i]. Ignorant of what had been taken from her, Leilani spent the next six years after her surgery institutionalized. Life at the institution was a stark contrast from her previous home life; "I was starved at home and beaten constantly… at least at the institution I got to play with other kids and be a normal child"[i]

Alberta's Provincial Training School for Mental Defectives in Red Deer, Alberta. http://statismwatch.ca/1997/06/01/alberta-barren-the-mannings-and-forced-sterilization-in-canada/

Ironically, ten years after her mother watched her daughter fade into the distance of the Michener Centre, it would be her mother who gave her a second chance at freedom[i]. Her mother took Leilani to dinner and never returned her[i]. Despite the betrayal of her initial abandonment Leilani is cognizant of the significance of her mother's actions "Do you realize what kind of life I would have had if my mother hadn't taken me from there?"[i]

In 1971, Leilani's experience at the Michener Centre came into full view when her doctor informed her that she had been sterilized. It was not until she sought legal assistance to sue the Alberta government, that she became fully aware of the results of her IQ test and the ruling of the Eugenics Board[i]. Her initial IQ was 64, but when she was later tested as an adult her IQ was 101[i]. The limited testing of Leilani did not take into account the effect of her physical and emotional abuse on her ability to take the test. Muir's case was awarded $740, 000. 00, but Leilani contends that 'money can't replace what was taken away'[i].

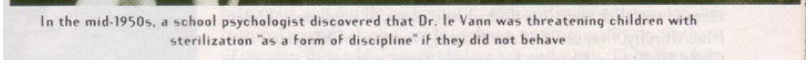
Leilani Muir.
http://www.imht.ca/imht_leilanimuir.html

In the mid-1950s, a school psychologist discovered that Dr. le Vann was threatening children with sterilization "as a form of discipline" if they did not behave

Sadly, Leilani Muir is only one of 2834 people sterilized in Alberta[xlii]. The Alberta Sterilization Act was enacted in 1928, on the basis of many emerging theoretical social perspectives, most notably Social Darwinism. Herbert Spencer believed that the ills of society could be removed if those individuals lacking desirable traits failed to procreate; society was capable of evolving into a more civilized form[iii]. It was Spencer who reinterpreted the work of Darwin and coined the term "survival of the fittest". During the 1920s and 1930s, many sociologists and scientists suggested that deviance may be the consequence of an individual's biological destiny. There was also a growing body of empirical evidence suggesting that certain 'undesirables' were out-breeding the rest of the population[iii]. Emily Murphy, the first female judge in the British Empire lamented "the congenitally diseased are becoming vastly more populous than those we designate as the 'upper crust'"[i]. Some researchers suggested that all degenerates could be bred out of the population in as little as three generations[iii].

Many different types of solutions were considered; marital counseling would advise the unfit not to procreate, segregation of the unfit would prevent them from combining their genes with an equally dismal partner and finally, sterilization[iii]. Other programs advocated for increased reproduction among the white middle class families as a woman's "true contribution to society lay in her potential to procreate.[iii]"

Eugenics, meaning 'good genes', has been practiced for centuries by livestock and agricultural breeders. Some suggest the primarily agricultural basis of Alberta made citizens particularly receptive to the Alberta Sterilization Act. The program was founded on a scientific basis that was held above reproach. Legitimacy of the Eugenics board was achieved through its close association with the University of Alberta and the data-driven decision making process for identifying candidates for sterilization. Candidates consisted mainly of marginalized groups such as women, youth, Aboriginals and immigrants from Eastern Europe[iii]. All of these groups were statistically overrepresented in the pool of sterilization candidates when compared to Alberta's population demographics at the time. The Eugenics Board was dissolved in 1972[xliii]. Investigation by researchers revealed that


In the mid-1950s, a school psychologist discovered that Dr. le Vann was threatening children with sterilization "as a form of discipline" if they did not behave

the decision to sterilize individuals was based on one IQ test and an average of 13 minutes of discussion by the board[iii]. The board approved 99% of all cases presented to them for sterilization; it deferred decision making on the remaining 1%[iii].

Perhaps the greatest irony of the history of Eugenics in Alberta is that the timeline of this practice, for a time, ran parallel with the socially condemned ethnic cleansing programs of Nazi Germany. Did the scientific basis of eugenics hold it in higher authority than the practices in Europe? How did the 'upper crust' reconcile their civility and adherence to the constitution with the practice of Eugenics?

There are some who vehemently defend the Alberta Sterilization Act and suggest that eugenics has taken a new form. 'Newgenics' refers to medical practices that ensure genetic quality among our offspring. Practices such as karyotyping to check for chromosomal abnormalities such as Down Syndrome, genetic sequencing to determine if an embryo will carry any undesirable traits and gene therapy where defective genes can be replaced with functional ones, all serve to better our gene pool. Based on the outcome of genetic profiles, parents can choose to abort their fetus or carry on with the pregnancy. Individuals opting for in-vitro fertilization can choose which embryos are implanted based on their genetic code. The rapidly expanding field of genetic modification may soon offer parents the option of 'designing' the genes of their progeny. These contemporary examples all beg the question; has scientific progress once again outpaced our ethical consciousness? Are we looking at Alberta's Sterilization Act through eyes of condemnation only to be blind to the current issues facing us?

[xl] Cairney, R. (1996). Democracy Was Never Intended For Degenerates: Alberta's Flirtation With Eugenics Comes Back to Haunt It. Canadian Medical Association Journal. Sept. 15; 1966;155

[xli] Alberta Heritage Community Foundation. http://www.abheritage.ca/abpolitics/people/influ_eugenics.html.

[xlii] Grekul, J., Krahn, H., Odynak, D. (2004) Sterilizing the "Feeble-minded": Eugenics in Alberta, Canada, 1929-1972. Journal of Historical Sociology. Vol. 17 No 4.

[xliii] Mc Whirter, K. G., Weijer, J. (1969) Statute: The Alberta Sterilization Act: A General Critique. The University of Toronto Law Journal, Vol. 19, No. 3 Summer 1969 pp.424-425.

APPENDIX B

STUDENT SURVEY

Biology 30 Survey

Question 1: How would you rate your interest level in the content of Biology 30 compared to other classes?				
	Very interested	**Somewhat interested**	**Somewhat disinterested**	**Not at all interested**

Why did you answer question 1, the way you did?

Question 2: How would you rate your overall confidence in Biology 30 compared to other classes?				
	Very confident in abilities	Somewhat confident in abilities	Not very confident in abilities	Not at all confident in abilities

Why did you answer question 2, the way you did?

Question 3: What instructional aspects helped you understand the material the most?					
	Really helped	**Sort of helped**	**Didn't really help**	**useless**	**Explain why this strategy is effective/ ineffective for you.**
Notes booklet					
Reading the text					
Teacher instruction					
Labs and activities					
Video					
Your own study methods					
Science stories- Did You Know? section of notes .					
Biology 30 Collectives					
Asking questions during instruction					
Listening to interesting stories about the content					
Other (describe)					

APPENDIX C

CAT DATA

CAT Data Collection:

Please summarize the applicable biology 30 content discussed in each of the following narratives in one to two sentences. Try to recall as many terms, or concepts as possible. In addition please rate how easy it is for you to recall this information and provide a reason why. If you have any questions at all, please feel free to ask.

Narrative	**One or Two Sentence Summary**	**Recall Rating (1-5) 1-very difficult to recall 3-can recall general story and main ideas, but some facts are fuzzy 5- easy to recall many details**	**Reasons why you feel the information was easy or difficult to remember. Feel free to comment on any aspects of the narrative (topic, writing style, bio content etc.)**
Freak Show-Endocrine System			
Goat Gland Doctor-Reproductive System			
Super Male XYY-Asexual / Sexual Reproduction			
Fatal Familial Insomnia-Genetics			

CAT2 Data Collection:

Please summarize the applicable biology 30 content discussed in each of the following narratives in one to two sentences. Try to recall as many terms, or concepts as possible. In addition please rate how easy it is for you to recall this information and provide a reason why. If you have any questions at all, please feel free to ask.

Narrative	**One or Two Sentence Summary**	**Recall Rating (1-5) 1-very difficult to recall 3-can recall general story and main ideas, but some facts are fuzzy 5- easy to recall many details**	**Reasons why you feel the information was easy or difficult to remember. Feel free to comment on any aspects of the narrative (topic, writing style, bio content etc.)**
The Upper Crust- AB Sterilization Act- Genetics			
Growing Despair- Gen. Modified Foods in India- Genetics			
Most Dangerous Game- Hunting Effects- Populations			
Collapse- human pop. Growth- Populations			

APPENDIX D

FOCUS GROUP INTERVIEWS

Biology 30 Interview Questions:

What do you like/ dislike about the collectives?

How have the collectives impacted your learning?

What did you like or dislike about the narrative?

How did the narrative impact your learning?

How did the narrative affect your interest in this course, compared to other instructional tools?

APPENDIX E

TEACHER FIELD NOTES

Qualitative Data:

Field NOTES:

Endocrine System Date: Feb. 22
Teacher Notes:
Had the students silently do the reading and then we discussed it as a class. Instead of teacher moderated dialogue, there were students talking to each other as a group. It was rather chaotic. The noise level and energy level of the students were significantly higher during the intervention. Numerous side conversations took place during the discussion phase. Most were on topic as students were pointing to the pictures on the worksheet and many asked me individual questions afterwards.

After the reading we went through the thyroxine loop as direct instruction. Felt more in control.

After doing some reinforcement exercises on hormones (questions sets) we continually returned to the story. At the end of the section students broke into groups of 2-3 and were asked 3 questions:

- What hormone imbalance did the werewolf man have?
- Draw a regular feedback loop for the hormone in question 1
- Draw the feedback loop that the werewolf man would have.

Students had a fairly easy time applying the loop to the wolfman scenario. Students continued to ask questions regarding the example during this exercise.

Reproductive System: Date: March 7
Had the students read the article after going through male anatomy and the feedback loop for testosterone. After reading allowed the students to ask whatever questions popped up while reading. After informal discussion had the students break into small groups of two to answer the following questions:

- Draw the regular feedback loop for testosterone
- How would the goat gland doctor implants alter this loop
- Was this cure possible?

Then discussed questions as a class.

Lots of questions- many students asking questions as they went through the reading

Asexual/ Sexual Reproduction- born criminal Date: April 13
After discussing non-disjunction had the students read the article. Student directed questioning followed by specific questions:

- How did the XYY arise?
- Why do XYY males have increased masculinity?
- What tests would you need to perform to diagnose this disorder?
-

Genetics- fatal familial insomnia- Date: April 20
After discussing pedigrees had the students read the article. Student directed questioning

followed by specific questions (on narrative sheet). Ethical discussions regarding genetic screening.
Genetics- The Upper Crust Date: April 27 The story for this narrative is of local interest as the event occurred in Alberta. Many of the students made connections between the sterilization program and the eugenics program practiced by the Nazis. The students made many inquiries as to how IQ tests are performed and how this information is interpreted.
Genetics- Growing Despair Date: May 2 The students discussed some of the concepts of globalization that they had learned in Social 10, a course I had taught them. They were able to correctly apply the concepts of multinational corporations, exclusive economic zones, trade liberalization and austerity programs. Student debate focused on the question of: who is responsible for controlling multinational corporations?
Populations- the Most Dangerous Game Date: May 16 The students were generally quite interested in this narrative because hunting is a large part of the culture of Grande Cache. There were quite some polarized views on whether or not hunting is an ethical practice. Students identified the pros of hunting- no transportation costs, generally sustainable, no intensive agriculture, no hormones and the cons of hunting- hunter has to kill the food, can cause disequilibrium in population, trophy hunting selects for negative traits in the population.
Populations-Collapse Date: May 30 After students read the narrative we watched a short national geographic video clip on world population. The video presented a number of stats regarding our projected population growth and the strain this will have on the earth's resources. In student discussion, both the video and narrative were referenced.

APPENDIX F

TEACHER REFLECTIVE LOG

TEACHER LOGS

Endocrine- Freak Show

What went well: students were very enthusiastic and asking many questions.
"Why don't people exist like this today?"
"Do you think the freakshow is any different than how we treat different people today?"
"How much did the 'entertainers' get paid?"

Reasons for it going well (3)
Pictures of the endocrine disorders
Empathize with the individuals in the article
Interested in the societal treatment and identification of 'freaks' in society

Challenges:
Felt a bit out of control- discussion seemed more like stream of consciousness than a directional conversation. Most points were discussed, just not in a directional fashion. Could possibly put a skeleton discussion on the board to progress in a more organized fashion

Reproductive-Goat Gland

What went well: students were interested in the entrepreneurial spirit of Dr. Brinkley- touched on science as a money making enterprise, bias, vested interest, research validity.

Reasons for it going well (3)
Discussed the nature of science and how Dr. Brinkley's experimental claims do not fulfill validity and reliability foundations of science
Students were interested why there were so many people duped by the conman- discussed placebo effect
Students made many funny jokes about the material "I want to be young so baaaaaaddd" "with more testosterone I bet the guys could grow some serious goatees" "instead of calling them gonads you could call them goatnads" made a very positive learning environment.

Challenges:
Some students insisted on using improper terms for the goat testicles… the discussion strayed off topic some inappropriate comments regarding sexuality. Decreased the level of intellectual examination. Ideas on a better way next time? I would try to silence the one student trying to steer the conversation in his own direction. Once other students would get talking about the science content, I think he would get on board.

Asexual/ Sexual- XYY

What went well: students seemed to get absorbed into the narrative more quickly- as soon as I passed it out, they were reading it and there were very little sideways discussions that weren't on topic.

Reasons for it going well (3)

A few students like the more story-based approach of this particular narrative
Positive comments when the narrative was being handed out "I really like these things- they are interesting" "What crazy story do you have for us today?"
Broke up some of the monotony of teaching meiosis- I liked the change of topic

Challenges:
not as many questions following the narrative (3 students missing from class). Tried to get the class talking about the ethical dilemma of screening people for criminal disposition and then tracking them… but there was little engagement. After significant prodding, I moved on in the lesson. Teacher: What groups of people might be in favour of genetic screening for criminal disposition? *Not the criminals.* Would you have your child tested? *Probably not… what if they started looking at me?* Is this an ethical practice? *Yes- it might prevent someone innocent from getting hurt.* What could be some potential benefits? *Tracking the criminals.* Who should gather and have access to this type of information? *The government.*

Genetics- Familial Insomnia

What went well: students were very empathetic towards the affected individuals and questioned personal genetic screening for themselves. "That would be a horrible way to die" "I would definitely get the testing for a fetus if I knew the disease was in my family- I may consider having an abortion if the child had the disease"

Reasons for it going well (3)
Had a video clip that coincided with the article where two sisters that could potentially have fatal familial insomnia were interviewed. One decided to get tested, one did not – this spurred on discussion about whether the students would get tested if they were in a similar scenario.
Discussed how genetic testing could be used to discriminate against people
Students discussed how life in the asylum at San Servolo would be and the reason the society made an asylum on an island. The students felt that mentally ill should be cared for institutionally if they are a danger to themselves or others. There should only be as much intervention as necessary and many people should make the decision for what care is best.

Challenges:
One student felt that the video was redundant and boring (he has a very short attention span) and just wanted to get on with the homework and the rest of the lesson. His comments seemed to cut the second round of potential discussion short for the whole group. Some students had side conversations with me about the narrative once work time had commenced.

APPENDIX G

NARRATIVE RANKING

Narrative Ranking

RANKING INTEREST: Order the following narratives from 1 to 8, with 1 being the most interesting and 8 being the least interesting.

Rank	Narrative
	"Freak Show"- Hormonal Disorders- Endocrine System
	"A Boy Named Billy and the Quest for the Fountain of Youth" – Goat Gland Doctor- Reproduction
	"Born Criminal"- XYY super males- Asexual/ Sexual Reproduction
	"First Do No Harm"- Fatal Familial Insomnia- Pedigrees- Genetics
	"The Upper Crust"- AB Sterilization Act – Genetics
	"Growing Despair"- Genetically Modified Foods in India- Genetics
	"The Most Dangerous Game"- Hunting Effects- Populations
	"Collapse"- Human population growth- Populations

Comments: Why did you rank the narratives the way you did?

RANKING RETENTION: Order the following narratives from 1 to 8, with 1 being the narrative that is easiest to recall the Biology Content covered and 8 being the most difficult to recall the biology content.

Rank	Narrative
	"Freak Show"- Hormonal Disorders- Endocrine System
	"A Boy Named Billy and the Quest for the Fountain of Youth" – Goat Gland Doctor- Reproduction
	"Born Criminal"- XYY super males- Asexual/ Sexual Reproduction
	"First Do No Harm"- Fatal Familial Insomnia- Pedigrees- Genetics
	"The Upper Crust"- AB Sterilization Act – Genetics
	"Growing Despair"- Genetically Modified Foods in India- Genetics
	"The Most Dangerous Game"- Hunting Effects- Populations
	"Collapse"- Human population growth- Populations

Comments: Why did you rank the narratives the way you did?

Narrative Evaluation

Narrative	**Interest ranking (1-5) – how well did the content/ topic/ writing style motivate you to keep reading? 1= very engaging 3= somewhat engaging 5= not engaging**	**Content Knowledge (1-5) – how well did the narrative address the content knowledge? 1= addressed thoroughly 3= addressed in general detail 5= content addressed only superficially**
"Freak Show"- Hormonal Disorders- Endocrine System		
"A Boy Named Billy and the Quest for the Fountain of Youth" – Goat Gland Doctor- Reproduction		
"Born Criminal"- XYY super males- Asexual/ Sexual Reproduction		
"First Do No Harm"- Fatal Familial Insomnia- Pedigrees- Genetics		
"The Upper Crust"- AB Sterilization Act – Genetics		
"Growing Despair"- Genetically Modified Foods in India- Genetics		
"The Most Dangerous Game"- Hunting Effects- Populations		
"Collapse"- Human population growth- Populations		

- Which narrative helped you understand a difficult concept in biology the most? Explain how it helped you.

- What modifications or changes to the writing style would have made the narratives more interesting for you personally?

- Additional Comments:

APPENDIX H

NARRATIVE CLASSIFICATION

Classification of Narratives:

I have written a series of 8 science narratives to coincide with specific units in Biology 30 as part of my master's degree research project. A science narrative is a factual story that employs stylistic writing components, usually associated with fictional works, to increase student interest and engagement. As part of my data collection I would like to determine if there is a correlation between the degree of narrativity of the science narratives and student retention and performance on chapter tests and the diploma exam. I would like you to read the 8 narratives enclosed and place them on the following spectrum.

#1- Freak Show	#5- The Upper Crust
#2-Goat Gland Doctor	#6-Growing Despair
#3- Born Criminal	#7- The Most Dangerous Game
#4 –First Do No Harm	#8-Collapse

Please place the number of each narrative where you think it belongs on the spectrum.

Expository Style

- Expository writing is writing that is designed to inform, explain, describe, or define the author's subject to the reader or explain what is difficult to understand.
- Ex. Textbooks, instruction manuals

Narrative Style

- Narrative Writing tells a personal or fictional experience or tells a story based on a real or imagined event. Often employs the stylistic components of fiction writing.
- Ex. Short stories, novels etc.

APPENDIX I

PERMISSION TO USE GRAPHIC

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Grande Yellowhead Public School Division

Re: permission to use graphic

Desktop • Mailbox • Re: permission to use graphic

From: "Stephen Klassen" <s.klassen@uwinnipeg.ca>

Saturday, April 21, 2012 12:49 PM -0600

Subject: Re: permission to use graphic

To: **Marcie Reuer**

Attachments:

RU in Sci&Ed.pdf	320K
SDCA.gif	158K
Attach0.html	3K

Hi Marcie,

I am delighted to hear about your project and its success. In particular, it is rewarding to me to know that you have been able to make profitable use of my model. I would be interested in receiving a copy of your completed work as I am continuing to work in the area myself.

Of course, you have permission to use the graphic. In case you need a higher resolution version, I have attached such a file. I have also attached a copy of my

most recent publication on the use of stories.

Best regards,

Stephen Klassen

Stephen Klassen, Ph.D.

Associate Professor

University of Winnipeg

Winnipeg, Manitoba R3B 2E9

Tel. No. (204)786-9020

e-mail: s.klassen@uwinnipeg.ca

>>> "Marcie Reuer" <marcreue@gypsd.ca> 4/20/2012 5:45 pm >>>

Hello Dr. Klassen,
I am completing my masters degree through the University of Montana and

I am working on my literature review. I have read many great articles by

you and your colleagues. My Capstone is on the effect of narratives on

interest and retention of concepts in high school biology. I was hoping I

could use your " A Schema for the Story-Driven Contextual Approach

(Klassen, 2007)" in my Capstone paper, with proper citation of course. I

think it is an excellent graphical representation and it would enhance my

project greatly. My research has shown that using

narratives dramatically

increases exam performance for average and low achievers with a marginal

effect on high achievers (students with over 80% on their diploma exam).

Thank you for your time and attention!

Marcie Reuer

Grande Cache Community High School

APPENDIX J

INSTITUTIONAL REVIEW BOARD APPROVAL

MONTANA
STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

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Chair: Mark Quinn
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Administrator:
Cheryl Johnson
406-994-4706 or 6783
cherylj@montana.edu

MEMORANDUM

TO: Marcie Reuer

FROM: Mark Quinn, Ph.D. Chair Mark Quinn ex
Institutional Review Board for the Protection of Human Subjects

DATE: March 9, 2011

SUBJECT: *"The Effect of Science Narratives on Student Content Retention and Interest in High School Biology" [MR030911-EX]*

The above research, described in your submission of March 7, 2011, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 101. The specific paragraph which applies to your research is:

___ (b)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

___ (b)(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b)(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (b)(5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

___ (b)(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

Informed Consent Form

Authorization for a Minor to Serve as a Research Participant

Dear Parents,

I will be conducting a study in our classroom to determine the effect of using science narratives on study performance and interest in Biology. A science narrative is a high-interest story or case study that describes science in a particular context. Previous studies have shown that providing a context for the science course content helps students apply their knowledge of the course to novel scenarios, similar to the types of scenarios on the diploma exam. I am writing to ask permission to use the data I collect from your child during this process. Participation in this study involves only regular classroom activities. You may contact me at any time regarding your child's participation, by phone 827—3502 or by email marcreue@gypsd.ca.

The study will take place during regular class time and will be part of regular instructional activities. The study will last for the remainder of the semester. To determine the effectiveness of the science narratives on student learning and interest in biology I will examine previous performance in Biology 20, performance on exams in Biology 30, student surveys and a videotape of the class to gauge student interest. The video will be used for data collection purposes only and will be destroyed after the data has been gathered. All students will be assigned a student number in the published data to ensure the privacy of the students. Your child's participation in this study is strictly confidential. Should you choose not to have your child participate in the study, he/ she will participate in the regular classroom activities, but their data will not be included in the study. Participation is voluntary. Participation or nonparticipation will not affect a student's grade or class standing in any way.

The benefits of this study include exposure to new instructional methods and increased student engagement and input into the instructional methods.

Use of data from your child is voluntary. You may contact me at any time if you don't wish to have your child's data used in the study.

Parent Consent: Please check the appropriate box below and sign the form:

- o I give permission for my child's data to be used in this study. I have read this form and understand it.
- o I do not give permission for my child's data to be used in this study.

Name of Parent/ Guardian:	
Date:	Signature:

Student Assent: Please check the appropriate box below and sign the form:

- o I would like to participate in this study and have my data used. I have read this form and understand it.
- o I would not like to participate in this study and have my data used. I have read this form and understand it.

Name of Student	
Date:	Signature:

APPROVED
MSU IRB
03/09/2011
Date approved
NA
Expiration date