THE ART AND SCIENCE OF INFORMATION DESIGN

by

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ABSTRACT

The Art and Science of Information Design

This thesis considers the new field of information design and how it is permeating the business world and filtering into higher education through science. Innovators in the information design world have invented a niche for this new field and have created new titles such as “information architect”, “information designer”, and “information journalist”. The problem is that although there is a demand for information design there is not enough awareness of how it can be used to enhance teaching, course content and student learning. In addition, because there is a disconnect between the expertise in the business world and those who are using information design in higher education, the potential for how higher education can be an incubator for information design has not yet been realized. In the design world there are connections between the scientific community and information designers, which yields sophisticated and innovative products. There is a lot of excitement in the design world and among those who teach design courses, yet this excitement has not yet extended to how this can apply to the teaching of other disciplines, such as science, nor how it can be used more effectively in K-12 education.

The thesis is based on a series of case studies about the demand, rationale, and application of information design in early childhood settings, higher education courses, and continuing education settings. The methodologies used were survey and document analyses, observations, interviews, and participation in conferences. The methodological approach was complemented by a phenomenological analysis in which the focus is on the essence or structure of an experience with an emphasis on experience and interpretation.

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CHAPTER I
INTRODUCTION AND METHODOLOGY

The seed for my thesis topic was planted several years ago when I read Richard Florida's *The Rise of the Creative Class* (2002) and learned about a population he fleshed out and profiled called the "creative class," which consists of creative individuals who possess high degrees of talent, tolerance, and technology savvy. Florida's work is considered to be part of a new wave of scholarship on urbanism because his creative class happens to be drawn to, and cluster in, specific cities. His theories of new urbanism interest me because there is an economically beneficial "super creative core" of individuals who are not just designers, writers, and architects but also scientists, engineers, professors, and other opinion-makers who bring innovation and creation to cities.

Progress and innovation support the knowledge-based economy. Over the past two years, my conviction that creative capital is important to economic and societal health has deepened due to the combination of witnessing the United States economy decline and being grossly interested in politics, policy, and current events.

More specifically, I think that design thinking has a vital role to play in addressing this economic shift and information design appears to be an important expression of it. IDEO CEO Tim Brown defines design thinking as going beyond conventional design skills by including strategically progressive ideation to tackle complex problems (2009, p. 7). Information design can be thought of as the creation of meaningful visualizations of information, qualitative or quantitative, using design thinking. Charles Tate (2008), a researcher at Georgetown University, calls for a focus on information visualization as a means of dealing with information overload because visualizations convey large amounts of information more effectively than text (p. 4).

Since my personal experience is in a creative industry—working as an advertising art director and designer—I have gained insight into what creativity means in a business-related context and how design can be moving, magical, and highly useful for clients. Yet, businesses are not interested in the individual, human experience with design; just with how design can augment their revenue. Those

working on the creative side of advertising get to use creativity all day long to create and come up with great ideas, however this energy goes into helping companies build businesses and unfortunately not into helping people build a better world. I believe that the creative problem solving that goes into the business world could be better utilized in a meaningful way to help educate students. The information age has ushered in so many technological innovations that are having major global economic and cultural ripple effects. If the goal of schooling is to prepare a person for a full and meaningful life in society and for vocational or career success, then information design can be seen as an important part of learning. This is because of its contribution to the creative economy—which is a critically important economic sphere—as well as to a person's individual understanding and interpretation of the world around them.

My investigation into these areas has given rise to my research question, which is: Given that information design is still a nascent field, how is it being incorporated into different levels of science education from Pre-K up to continuing education? As I started reading about information design I discovered that there is a growing body of research and literature related to design and the economy, but not much related to my specific interest in information design. Part of the reason for this may be that information design is a relatively new field; it is not being practiced or promoted on a scale that reaches public consciousness. While design already has relevancy in the art room, I chose to take a cross-curricular approach to examining art education by specifically targeting science classes. Science helps design and design helps science; I wanted to investigate this intersection.

I wished to understand more about how information design reaches students and educators so as to then look at its utility in learning. Before considering information design's significance to different levels of education, it must first be deconstructed: What is information design? Where is it used in educational settings? Who is using it? By attempting to answer these questions it became clear to me that I would have to establish my population. Where are people being prepared for understanding and for using information design? In high schools? In higher education institutions? In continuing education programs? I therefore decided to look at how educators and students are engaged with information design throughout different school levels, from pre-school to higher education and continuing education. More specifically, I had the desire to find out how information design is incorporated into the specific subject area of science within higher education undergraduate classes. Through this research I was able to assess how effective and ineffective information design enters the classroom and what kinds of visualizations are being used for learning.

My research question emerged from my broad reading on the current state of the economy, on creative capital, and on existing uses of information design both in the United States and internationally. The United States' transition from a manufacturing to ideas-driven economy makes for a dynamic environment that is full of change and challenge. Design educator and historian Robin Vande Zande (2010) likens the call for education to improve design during the Industrial Revolution to the current need for design education in this unstable economic climate. Information design, also referred to as data visualization in practical contexts, stands out as a valuable design product for the information age.

It seems that there are beginnings of an information design revolution in the making. David McCandless' work is especially innovative. He is a writer and data journalist who draws visual conclusions from complex datasets, revealing unexpected insights into our world through design (McCandless, 2009). This field is fueled by real-world, everyday needs for innovation with regard to knowledge intake. McCandless' designs spring from a variety of data sets such as: rising sea levels, benefits of vitamins and supplements, sources of carbon dioxide emissions, and leading causes of death. Instead of several paragraphs of words, these curiosities can be explained through one complex visualization.

There are clear inception points of information design in continuing education. Two key figures that have been influential in shaping the direction of the field of information design are Edward Tufte and David McCandless. Both are prominent figures in their fields and are of different generations; Tufte is like the formalist father situated atop a figurative ivory tower and McCandless is like the hip, restless son bouncing from city to city. Tufte teaches a one-day seminar on presenting data and information that was included in my data collection. McCandless promotes his work through speaking engagements and an active web presence. These sources illuminate information design's utility in continuing education, yet they also shed light on information design's influence in other levels of education from pre-K to higher education. In light of the proliferation of data exposure in the information age, there seems to be great potential in examining how information design is used in science education.

Methodology

The fields of information design and visual thinking are experiencing growth because of greater public access to constantly evolving digital design programs and because of greater

communication possibilities due to the internet. In light of its budding state, information design has a nearly non-existent, or at least not explicitly defined, presence in education systems.

Since I am examining a nascent field, I conducted mini-case studies of how information design is used at the elementary and high school levels, as well as in higher education. My data collection involved these strategies: interviews, observations, and document analysis. The research is held together by small-scale case studies of specific educational settings to understand more about how information design is used in the classroom and in a continuing education context. A case study is a qualitative approach in which the "interest is in process rather than outcomes, in context rather than a specific variable, [and] in discovery rather than confirmation. Insights gleaned from case studies can directly influence policy, practice, and future research" (Merriam, 1998, p. 19).

Each case has a comprehensive analysis that provides contextual variables. The data from each unit of study was then analyzed by looking across the individual case studies. This helped define categories, themes, or typologies that conceptualize the data. The cross-case analysis helped build an integrated framework covering the multiple cases.

Parallel to the case study analysis was a phenomenological analysis in which the focus is on the essence or structure of an experience (phenomenon) with an emphasis on experience and interpretation. Sharon Merriam (1998) summarizes phenomenology: "The challenge facing the human science researcher is to describe things in themselves, to permit what is before one to enter consciousness and be understood in its meanings and essences in the light of intuition and self-reflection. The process involves a blending of what is really present with what is imagined as present from the vantage point of possible meanings; thus a unity of the real and the ideal" (p. 17). According to Merriam, in conducting this research, "a researcher must first have an intuitive grasp of the phenomenon and then follow up by investigating several instances or examples of the phenomenon to gain a sense of its general essence" (p. 16).

My research plan was to examine different levels of education and, where possible, their treatment of science education as it relates to information design. Starting from the top of the education ladder, one of my case studies focused on continuing education, which consisted of studying a professional development seminar given by the information design guru Edward Tufte. Another case study was that of Art Education University's science classes.[1] I also studied information design at the secondary school level by looking at the digital, media-oriented New York charter

[1] Art Education University is a fictitious name.

school, Quest to Learn. Lastly, I conducted a case study of the Reggio Emilia-style education model at The Blue School, which is also located in New York. I intended to observe science classes in higher education, however I also studied general applications of information design as they become evident in the absence of these classes. Since information design is so new, it made sense to seek it out where available so as to not limit potential avenues for study.

I planned to survey the research about the Reggio Emilia approach in elementary education, which has a heavy emphasis on design. There is extensive literature that discusses the Reggio Emilia approach, which is all about experience; it consists of engagement with theory and practice as well as further careful reflection in a program that emphasizes project-based work and documentation (Gandini, 2003, p. 26). The documentation is used to guide and direct children's work as well as to understand the children better and evaluate the teacher's work. Another tenant of the Reggio Emilia approach is the use of physical space in a way that fosters encounters, communication, and children's relationships with their peers (Gandini, 2003, p. 25). These aspects were closely examined, as they hold the greatest possibilities of providing insight into information design's presence in Reggio Emilia education. I also looked at school mission and branding, curriculum content, and student work. My study was informed by attending the conference, "Inquiry, Documentation and Relationship: Reggio Inspired Thinking and Practice," which was held in dialogue with Amelia Gambetti and Lella Gandini, who are affiliated with the original Reggio schools in Italy.

I then conducted an analysis of the visual identity and branding of Quest To Learn, a unique grade-6 through-12-school founded with partner Institute of Play, a non-profit that explores gaming literacy within a context of media ecology. Quest To Learn has a cohesive identity and tight mission statement. One of its main educational goals is the attainment of digital media literacy whereby students cultivate skills necessary for top college and career preparedness. Its model is designed to enable all students, with a diverse range of learning styles, to contribute to the design and innovation necessary to meet the needs and demands of a global society. I studied this school by thoroughly analyzing documents used by educators, parents, and students. Quest To Learn is important to this thesis because it has a clear connection to education with the present state of the world in mind. Moreover, their digital focus lends itself to design relevancy because of the digital media's inherently visual mode of communication.

Much of this thesis research focuses on a higher education study of science education at Art Education University. Two specific courses were chosen because of their high science content

and student body composition, which was that of art majors: Science and Society and Ecology for Architects. I analyzed the syllabi based on curriculum design, student work, and instructional activities. The study was supplemented by interviews with the professor who teaches these two courses. The goal of these interviews was to get a better sense of how teachers and students each use visual design communications tools in their classes that are, by their subject matter, inherently information-heavy. Additionally, I conducted classroom observations and spoke with students. The top of the educational ladder was a ripe area for my research because of the trickle-down nature of new educational concepts and systems.

Lastly, I put together a specified case study on a non-accredited continuing education programs and seminar that featured information design or a related topic. One of the larger components was participating in an Edward Tufte seminar and reviewing the associated books. Tufte's seminar was about presenting data and information; it featured topics such as strategies of analytical design, effective presentation on paper and in-person, and interface design. Another aspect of continuing education involved attending a seminar specifically about information design at The New School's art institution, Parsons. These seminars were aimed for an audience of working professionals looking to sharpen their skills. As I moved into my cross-case analysis, I paid special attention to the continuing education case as it relates to secondary and higher education so as to synthesize how a school's science classes relate to the information design used by the present work force.

My methodology aimed to answer my research question, which is: Given that information design is a nascent field, how is it being incorporated into different levels of science education from Pre-K up to continuing education? By looking deeper into this area, I planned to uncover how information design varies across different age levels, how it is incorporated into specific disciplines, and what the differences and similarities are among the different levels of implementation. While I will not be able to properly assess how my findings about information design in education actually influence the economy, I will consider how these developments relate to the theoretical discourse about information design's economic influence. While my research question explores the use of information design in science classes, the Pre-K level is too young for subject divisions; therefore, I will be looking across all subject matter and environmental design for my scope of research at this education level.

CHAPTER II
LITERATURE REVIEW

This thesis centers on information design in science education, however it provides a broader context for this work through a theoretical analysis of the importance of information design to the creative economy. Therefore, the first section of the literature review considers the literature in the field of creativity and its relationship to creative capital, written by researchers in the United States and Europe. While the literature review provides a sense of the scope of this research, Chapter 3 will focus on some of the particular aspects of the creative economy. The second part of the literature review discusses the literature in the fields of design thinking and information design. And the final section of the literature review focuses on design education.

The Creative Class and the Economy

John Howkins is a consultant from the United Kingdom with keen knowledge about creative industries and expertise in the development of the creative economic sector in China. Howkins directly addresses the creative economy in his book, *The Creative Economy: How People Make Money from Ideas* (2002) in which he examines the close relationship between creativity and economics. Howkins (2002) broadly defines creativity as the ability to generate something new and further defines it as the production of ideas and inventions that are personal, original and meaningful; it is a talent, an aptitude. Creativity occurs whenever a person says, does or makes something that is new; it is present in thought and action. Pasi Sahlberg and David Oldroyd (2010) define creativity as the inventiveness to come up with new ideas, processes, and products that have value, and they position it to be as important as literacy in education. Similarly, Richard Florida (2003) has long advocated for investing in creative infrastructure, which happens through financing R&D centers and, more generally, furthering the cultivation of creativity in education by means of innovative inquiry. His research centers on the argument that the economic success of a region is determined by its capacity to attract talented people who are technologically adept and tolerant of others who are different (the

three ‘T’s); these people are known as the Creative Class.

Now more than ever, creativity is viewed as an important economic asset. Even in Europe researchers are being issued government grants to explore how education can lead to economic competitiveness as well as how to monitor and measure creativity. Richard Florida has underscored the importance of creativity to the economy since writing his book, *The Rise of The Creative Class* (2003), in which he defines a whole population that is the economic undercurrent in revitalizing cities. Florida argues that the city needs to appeal to and synergize with those in the creative class since it is these people who are contributing creative capital to the economy. Pasi Sahlberg focuses his research on reforming education to fit with a sustainable knowledge economy. Writing with David Oldroyd, Sahlberg (2010), unlike Howkins and Florida, calls for an investment in sustainability since it is of utmost importance given the global environment’s manmade decay.

Pasi Sahlberg, who is originally from Finland but works all over the world, is conducting research at the behest of the European Union. This is important to consider because Europe’s increasing attention to creative capital highlights the United States’ inattention in creating effective policy as a reaction to the importance of cultivating this type of capital. John Howkins describes the different types of capital, of which the human and intellectual types contribute to the knowledge economy.

Carrying the argument further into practicality is Ernesto Villalba (2010)—a researcher from Spain who has worked in Sweden and Italy—who attempts to, also on behalf of the European Union, deconstruct creativity. He responds to the European Union’s challenge of how to measure creative and innovative skills at an aggregate (societal) level as opposed to the other more psychological perspective by presenting competing theories. Villalba rightly cites Richard Florida as being the foundational catalyst and the beginning of a movement, but finds flaws as he expands upon Florida’s theories. One flaw is Florida’s broad data and his use of correlational evidence. Villalba also believes creativity to be more complex and that a study of it should include entrepreneurship, which Florida does not wholly consider.

Each of the four researchers discusses creativity and its economic role along with its educational implications. Sahlberg and Oldroyd (2010) understand the value of the sustainable school and see it as a great risk to continue with the irrelevant industrial model of education—the banking system—that values standardization as the driver of policy; it fails to produce the human and social capital that could be generated by redirecting formal education towards greater creativity and

collaboration. Howkins, Florida, and Villalba would all agree with this statement.

There remains, then, the issue of how to cultivate creativity in the education systems. Sahlberg is currently conducting research on this topic at the secondary school level. Florida writes generally of education in his other books. Howkins (2007) maintains that the growth of creativity is likely to outgrow all other economic areas in the global information infrastructure and, as such, investments in education, research, and thinking increase creativity's value and effectiveness. Many of these ideas seem to suggest that some of this new focus on creativity could be lodged in art education, especially considering Howkins' closing: "A society that stifles or misuses its creative resources, and signs up to the wrong property contract, cannot prosper. But if we understand and manage this new creative economy, individuals will profit and society will be rewarded" (p. 220). Also, there are similarities between Howkins and Sahlberg's attention to sustainability. Villalba (2010) actively attempts to assess the different components of creative learning by supporting the formation of a complex computer database as he yearns to connect many theories and theorists; he even describes creativity as a polygon, a geometric figure.

Design Thinking and Information Design

One of the most prominent and formalist figures in the field of information design, Edward Tufte, has written a number of books on the subject (Tufte, 1990; Tufte, 1997; Tufte, 2001; Tufte, 2006a; Tufte, 2006b). He unites structure and design in complex visuals and has been an inspiration for designers and non-designers alike. To illustrate his influence, Tufte holds all-day seminars on the utility of design for presentation use by working professionals.

The field of design thinking came into fruition, after Edward Tufte caused a stir in the design world, as a result of needing a name for the substance and strategy behind beautiful visuals. Tim Brown, CEO of the firm IDEO, helped herald in its existence through his book, *Change by Design* (2009). He describes design thinking as going beyond conventional design skills by implementing strategically progressive ideation to tackle complex problems. Brown also lays down the principles of design thinking as: user-centered research, brainstorming, analogous observation, and prototyping. Additionally, Brown is an advocate of a human-centered approach to drive innovation and growth for organizations. Other experts in the field, such as Daniel Pink, have also used the term (Pink, 2006). Although design thinking has emerged just in the last decade, its growing presence speaks to its usefulness and applicability. However, design-literate business executive and industry consultant Don

Norman chastises design thinking by calling it a myth and sales tool. "We have had breakthrough ideas and creative thinking throughout recorded history, long before designers entered the scene," argues Norman. He contends that using the term "design thinking" benefits design consultancies and the like because "the emphasis on 'thinking' makes the point that design is more than a pretty face: it has substance and structure" (Norman, 2010). Yet this is exactly what design thinking aims to do: educate the public to the fact that there is substance and structure to design thinking. By laying out explicit principles, techniques, and examples, those who advocate for design thinking are simply looking to further the benefits provided by the practice for the good of society. The various sources on design thinking are scattered throughout company mission statements, blogs, and articles. Given its newness, much of the research on design thinking that currently exists is in the realm of mass media and communications where it meets an immediate need for designers and their audiences rather than in academic journals.

In academia, however, Charles Tate (2008) did a study of visualization tools to mitigate information overload for his Master's thesis. Tate claims that technology has developed at a rapid pace, creating access to scores of information, but the human brain cannot keep up with the consumption. Elaborating on how we are drowning in information, Tate narrows in on more specific problems with processing information by finding relationships and patterns in the data. His research into the issue consists of examinations of 50 examples of visualization tools as well as surveys of undergraduate and graduate students that he used to demonstrate the visualization tools' success. While not explicitly about design thinking per se, Tate's thesis focuses on how visualization tools can help design thinkers. Tim Brown would agree with Tate's premise, but might encourage more exploration of how innovation can be served by such tools.

Since information design is a new field, much content can be found outside of academia in the realm of popular culture. An excellent example of the utility and application of successful information design can be found in David McCandless' book, *The Visual Miscellaneum* (2009), in which he assumes the role of an "information journalist" to draw conclusions from complex data sets by visualizing information that is otherwise overlooked, too complex, or scattered. McCandless (2009) presents over 100 designs that stem from his desire for a better way to understand, like Charles Tate, the boundless amounts of information all around us. In his introduction he writes that he wants the book to serve as a "modern day map book" that focuses "on the relationship between facts, the context, the connections that make information meaningful" (McCandless, 2009). *The*

Visual Miscellaneum can be understood as a pure example of creative problem solving by a design thinker. An example of one of the designs is "Stock Check" that visually layers estimated amounts, in years, of the remaining supplies of non-renewable resources such as zinc and oil (p. 42). Another example is "Dangers of Death" (p. 134) which is a spiral of causes of death from most likely to occur (heart disease) to least likely to occur (shark attack). Two traits each of his designs has in common are elegant presentation and clarity of visual comprehension. There are many different categories the designs can be sorted into; not surprisingly, McCandless applies design thinking to the creation of the table of contents in organizing it not by page number, but by category. This is reminiscent of Charles Tate's design of categories his 50 tools fall into such as: political, medical, science, language/semantic, business/economic, etc. (Tate, 2008, p. 28). One implication of these visualizations, as Tate explores in his research, is the question of visual literacy: how long it takes for someone to understand the visualization and their rating on the ease of use. A point of difference between Tate and McCandless is that Tate analyzes mostly interactive information visualizations while McCandless mostly works with static designs.

Visual Literacy in Design Education

Visual literacy appears to be one of the goals of design education. Pasi Sahlberg and David Oldroyd (2010), in response to the European interest in exploring creativity and realizing its economic utility through innovation, make the assumption that national economic competitiveness is linked to intellectual and creative capital. They lay out the current problems in education policy and prescribe solutions linked to visual literacy in design education. One big problem is that "in the quest for higher standards and better performance in international rankings, education systems are becoming more standardised and focused on 'core subjects', harmonised frameworks and key competences (Sahlberg & Oldroyd, 2010, p. 284). Sahlberg and Oldroyd (2010) go on to argue for a solution: "Being able to come up with new ideas, processes and products that have value should be raised to the same level of importance as that which literacy has enjoyed so far. This requires wider and more frequent use of adequate methods of teaching and work that promote collaboration, creativity and focus on students' individual talents" (p. 284). Economic competitiveness is the vehicle to promote this solution, which is centered on visual literacy.

Maria Velez-Rojas (2009), as a doctoral student in electrical and computer engineering, discusses visualization literacy, which she defines as the ability to successfully interpret modern science

information visualizations. Her dissertation supports the need to train the general population for the development of visual literacy, but her examples consist of very high-tech radiology-type visualizations meant for a specific type of higher education population. Pasi Sahlberg and David Oldroyd (2010) also support visual literacy and the cultivation of creativity; they view it as important as literacy in education because it feeds into inventiveness, which allows one to come up with new ideas, processes, and products. Their arguments can also be applied broadly to multiple populations. Velez-Rojas' methodology analyzes individuals' visualization comprehension under the control of cognitive abilities so that the factors involved in comprehension difficulty can be isolated for a training program to be developed.

Velez-Rojas (2009) advocates for visual literacy in curricula not just in art subjects, but also in areas like math and science. She also discusses The Visualization for Improved Scientific and Technological Literacy Education Project (Viste) as a vehicle for visual literacy. The project was devised in the 2003 American Society for Engineering Education Annual Conference in Washington, D.C. and it designed a curriculum to promote the development of knowledge in technology and mathematics (Velez-Rojas, 2009, p. 16). With secondary education in mind, Velez-Rojas briefly mentions researchers who propose to improve the current high school curriculum by going beyond basic drafting skills to include a visual science course. Maria Velez-Rojas admits that visualizations are not understood and so the techniques to teach them are not widely apparent. She proposes a methodology to extract the information required to develop generic visualization skills before acknowledging the current use of simple bar graphs and pie charts at the middle school level and how this could be improved.

In contrast, Sahlberg and Oldroyd (2010) argue that to advance visual literacy, educators should focus on social capital by promoting strategic alliances, collective intelligence, and team-based problem solving. Ideally, a creative pedagogy would be implemented that encourages: problem-based learning and creative problem solving; customized learning; availability of diverse knowledge sources; and the arts as the central thread for thematic learning (not compartmentalized learning).

To supplement the arguments for the implementation of design education and visual literacy, literature on the science of how to do so exists. Stephen Kosslyn (2006), a cognitive neuroscientist, is interested in the psychology of visualization; namely, why certain designs communicate effectively. Using eight psychological principles for constructing effective graphs, Kosslyn has each principle solidly rooted both in the scientific literature on how we perceive and comprehend graphs and in general facts about how our eyes and brains process visual information. One is the Principle of

Perpetual Organization, which holds that people automatically group visual elements into units that they attend to and remember. His research is beneficial for advanced populations such as post-secondary students, continuing education students, and teachers of these two populations. More narrowly, his research could greatly benefit science and math teachers, but it is not clear if secondary school students could learn from his research should their teacher use his work as lesson content.

Tim Brown (2009) devotes a chapter, entitled "Designing Future Designers", to design education. Brown (2009) believes the goal of this education is to "unlock the vast reservoir of human creative potential" (p. 222). Doing so requires educators to encourage and amplify children's natural inclination to experiment and create by nurturing their creativity as they advance through the educational system. A common thread throughout the literature on design education is the need for problem-solving-based learning where creativity and innovation are utilized.

IDEO, Tim Brown's company, plays an active role in promoting problem-solving in schools. One of their clients was Ormondale, a public elementary school in California, that uses tools and processes for teachers to activate participatory design, which engages students as seekers rather than receivers of knowledge (Brown, 2009, p. 223). In higher education, The Royal College of Art in London has collaborated with the Imperial College to give rise to creative problem solving found in art and engineering. Similarly, the Ontario College of Art & Design teamed up with the University of Toronto's Rotman School of Management to cultivate a shared pursuit of creativity and innovation (Brown, 2009, p. 224). Brown also discusses the work of the d.School at Stanford University where business students and professionals round out their education by including design thinking in curricula. However, Villalba (2010) argues that it is important to remember that education does not necessarily beget creativity, but that creative types do have more education. Villalba also argues that the lack of comparative international evidence to test hypotheses on effective creative education makes it difficult to determine the exact role of education in enhancing creativity; he calls for more complex measures of creativity.

While there is a relatively substantial amount of literature on creativity and, to a lesser extent, design thinking, information design remains relatively untouched by academia. The following chapter provides a contextual understanding of information design through an examination of the historical origins of the term, examples of information design, and prominent figures from the field. It also elaborates on the creative economy and education as a means for understanding the utility of design thinking and information design.

CHAPTER III
BACKGROUND CONTEXT

Information design is one example, or type, of design thinking that consciously and digitally presents information visually. Other terms for information design include data visualization and information visualization. There are subtleties in what each term implies; for example, "data" may conjure up images of myriads of hard numbers crunched on a computer screen. And "design" may evoke polished images, Adobe software, and a sense of composition. This grayness of definition speaks to the infancy of the field. It was roughly 5,000 years ago that the Egyptians manipulated data into calendars; and it was only about 20 years ago that we were able to digitally manipulate page layouts on personal computers.

Throughout history, creativity has helped in making personal, social and financial progress in the United States. The 18th century was propelled forward by the Enlightenment wherein divergent thinkers and innovators invented new ways of doing and seeing things. As machines began to gain prominence in the 19th century, society moved into the Industrial Age. This gave way to the Manufacturing Age that is now tapering off as we move into a knowledge-based economy. By the turn of the 21st century the United States was deeply involved in "outsourcing" labor, and manufacturing came to be embodied by domestic workers who became responsible for planning and ideas. This is especially apparent just by looking at dying cities like Buffalo, Detroit and Cleveland. However, it is important to note that manufacturing is another way to say creating. While we no longer create masses of tangible products, we do create masses of digital products.

Design Thinking

In order to further deconstruct design thinking, it is helpful to consider what design is and what designers actually do. Simply put, designers create things: objects, products, interactive experiences, media, printed material, interiors, etc. Designing runs from the grandiose such as the concept of God's intelligent design to the humble such as a kindergartener's food "sculpture" on his or

her lunch plate. Through conception and planning, a designer creates something with purpose.

Design thinking refers to a mode of cognitive function as it relates to improving the human experience. Tim Brown, CEO of the lauded creative firm IDEO, is a forerunner in the field. His firm employs design thinking across a wide range of disciplines, as this type of thinking transcends specific industries. For example, IDEO designed Apple's first mouse and built Prada's interactive dressing rooms in their New York City store. They also were responsible for developing Bank of America's highly successful "Keep the Change" program that automatically rounds up a customer's debit card purchases for deposit in a savings account. Brown (2009) fleshes out the concept of design thinking by characterizing it as tapping "into capacities we all have but that are overlooked by more conventional problem-solving practices…design thinking relies on our ability to be intuitive, to recognize patterns, to construct ideas that have emotional meaning as well as functionality, to express ourselves in the media other than words or symbols" (p.4). With innovation in mind, design thinking involves thinking up new ways to look at a problem and then shifting one's focus from problem to project by carrying an idea from concept to reality (Brown, 2009, p. 21).

Another figure in the business world is Daniel Pink who advises start-up companies on recruiting, practices and business trends. He has also contributed to *The New York Times*, *The New Republic*, *Harvard Business Review*, and *Wired* magazine. Pink authored the book *A Whole New Mind* (2006) that explores the power of creativity and innovation in modern economic development. It has been translated into at least 12 languages. Pink (2006) asserts that right-brain qualities such as inventiveness, empathy, and meaning-making are key strengths for economic health. The premise is that the qualities that left-brained individuals possess were responsible for the logic and precision that gave rise to the information age; and now, the qualities that right-brained individuals possess are giving rise to the new conceptual age (Pink, 2006). Pink essentially uses popular understandings of neuroscience as a metaphor for discussing the economy. Professional success is being challenged, as is personal fulfillment. While his arguments are convincing in their generality, they are also tinted with the slickness of marketing language. *A Whole New Mind* is best understood as a strong call to action for waking up business leaders and other influential figures to the reality of a world that requires creativity and design thinking.

There is some controversy surrounding design thinking, as some companies have been using the term as a shiny accessory for their businesses (Norman, 2010). It is easy to abuse the term by keeping it as a vague understanding and therefore a noteworthy buzzword. The exemplary,

authentic uses of design thinking run deep graphically and cognitively. Design thinking is more than just "design." To Tim Brown "design is more than enhancing a product's aesthetics or function, or improving a service. Designers have a higher calling. 'As designers, we have to be able to understand the world's complexity and we have to participate… We have the responsibility to attempt to solve those problems'" (Jingting, 2011). By allowing innovation to work for the benefit of human beings rather than strict profits, IDEO was given a $2.6 million grant from the Bill and Melinda Gates Foundation in 2009 to work with the non-profit Acumen Fund to bring clean water to regions in Africa and India (Jingting, 2011). Design thinking is a way of acting in the world by using innovation to make life better in a vast variety of ways where aesthetic appeal is combined with creativity and intelligent problem solving.

Information Design

Information design is an articulation of design thinking. The field of information design is very new. So new that it is difficult to arrive at a universally shared definition. There is also confusion created by the existence of the related, albeit also distinct, terms such as "data visualization" and "information visualization." For the purposes of this thesis, I define information design as the creation of meaningful visualizations of information, qualitative or quantitative, using design thinking. The actual creations subscribing to information design are called data visualizations. The field of information design will be introduced by looking at prominent figures in the field such as Otto Neurath, Edward Tufte, Richard Saul Wurman and David McCandless.

Although it is perceived to be a new field, information design is not a new concept. In the 1930s Austrian economist Otto Neurath created Isotypes, which are icon-like pictograms that enhance statistics; they became a basic tool initially used by social scientists, educators, and businessmen. Isotypes offer a type of "information aesthetics, which allows quick navigation based on intercultural common sense—they constitute a streamlining for easy judgment" (Hartmann, 2008, p. 289). The word "Isotype" is derived from International System of Typographic Picture Education. Isotypes were created using reduction so as to find the simplest expression of an object. Neurath's goals were twofold; they centered on education and information by providing an accessible, inter-cultural language system to all while also creating a new, unbiased way of understanding information outside of the written word.

Neurath's work dovetailed with society's increasing focus on "internationalization" that,

around 1900, came to signify the interconnectedness provided by technology like steamboats, railroads and the telegraph; also widely used were the terms "standardization" and "unification" (Hartmann, 2008, p. 288). Otto Neurath was a pioneer of modernity whose work is still felt by graphic designers nearly a century later. While Isotypes were not meant to be ways of graphically representing data, they do speak to the human need for making sense of the world through coding. Information design is not meant to be a language in and of itself; rather, it aims to provide a quicker way of cognitively processing so as to allow for an easier optical intake. Just as Neurath wanted Isotypes to level communication between different cultures and eradicate semantics, so, too, information designers seek to reduce processing time and the complexity of information. Prompted by information overload and supported by technological tools, designers are able to devise new ways of understanding the world around us, that in the 21st century is very information-rich and disorganized.

The internet has given us a wealth of information at our command in addition to a means of disseminating and communicating information. Fortunately, evolving computer technology has also given us applications in which to select and shape the information we have found while being connected to the world. According to the United States Census, in 1989 only 15% of United States households had a computer; in 2003 that figure jumped to 62%. In 2001 just 9% of United States households reported broadband internet use whereas in 2009 it soared to 64% (U.S. Department of Commerce, 2001; 2010). Also in 2009, 76% of United States households reported having someone use the internet from some location (U.S. Department of Commerce, 2010). The United States is enabled with the technology necessary to design and visualize information.

One of the most prominent figures in the graphic design world is Richard Saul Wurman (b. 1935), who is considered to be a pioneer in information design. Wurman holds a Master's degree in architecture and a Doctorate of Fine Arts. He is known for inventing the title "information architect" in 1976 to refer to those who bring care and order to the massive amount of information generated by society. Wurman has urged designers to "try to discover the obvious ways that make things clearer. Try to search for clarity" (Knemeyer, 2004). His insistence on achieving understanding echoes through the very core of information design; it is a field dedicated to making something more understandable through a visual representation.

One of the most respected individuals involved in the emergence of information design is Edward Tufte (b. 1942), who entered the field vis-à-vis the study of statistics and a PhD in political

science. Since the 1980s Tufte has produced several books that cement his place in the history of the development of information design and visual literacy. He has made information design accessible through his books and professional development seminars on presenting information. One of Tufte's strengths is his ability to discuss data visualizations down to the detail. For example, he has thoroughly analyzed the merits of sparklines (Figure 1), which he developed as visualizations to convey rich detail of quantitative data in a highly condensed form.

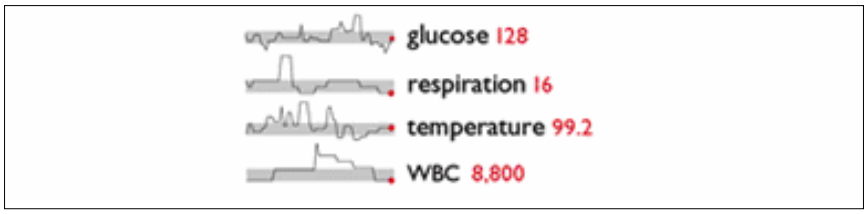

Figure 1. Edward Tufte's Sparklines (2006a, p. 6)

Good information design communicates effectively. Tufte famously proved its importance in his argument attributing poor data design to the 1986 Challenger space shuttle disaster (Tufte, 1997). Cluttered visuals and emphasis on the wrong elements in a report on the ship's O-ring damages were NASA's design missteps, as was its use of Microsoft PowerPoint to deliver that information.

Edward Tufte is known for his derision of the popular presentation software application, Microsoft PowerPoint, for its clunky design and lack of clarity. PowerPoint is responsible for cultivating poor representations of information design across the business world. It has reinforced meaningless, wasteful graphics for years. Tufte calls these graphics—that include built-in elements such as large arrows, bright burst bubbles, clip-art, 3D effects, and forced bullet point hierarchies—"chartjunk." This is not to say Tufte devotes all of his energy to criticizing bad design. He also highlights examples of good information design produced by himself or by others throughout history, and for good reason: information design is all around us.

Any graph presenting useful information one has seen on a nightly news television program, in a magazine article, or in an annual report is an example of information design. However, it goes beyond just simple pie charts and bar graphs. An important thing to remember is that quality has improved with digital technology. In a larger schema, however, digital graphics are brand new ways of consuming indiscernible quantitative data. Quark Xpress image layout software did not exist until 1987; Adobe InDesign, its rival, was not even born until 1999. Moving into the 21st century information age, there exists such an abundance of data that we use graphic representations to help

sort and make sense of it. Mouthfuls of paragraphs can be distilled down to one small bite. There is usefulness in this skill for the benefit of society.

Information Design and the Economy

An understanding of the current state of the economy is central to my thesis, as it sets the foundation upon which my research on information design education is based. As we move away from the manufacturing age and its industrial model of education, it is becoming more apparent that the knowledge-based economy is of crucial importance to the financial and social well being for individuals and society. Subsequently, there is a need to revisit education policy since the banking system—in which knowledge is a one-way gift bestowed by teachers and deposited into students—and its relics are no longer useful. One way of examining education is by looking to subject areas that the government deems important to the future health of the nation; these are referred to as STEM, which stands for Science, Technology, Engineering, and Math. Notably missing is art. However, there are ways of integrating creativity into these subjects if one is committed to doing so. This is where information design comes in. There is great economic benefit to be had by incorporating creativity into education curricula and many scholars and writers have addressed this with urgency.

John Howkins' *The Creative Economy: How People Make Money from Ideas* (2007) presents a grounded study of the relationship between creativity and economics. He examines and defines terms in useful detail; for example, he defines creativity as "the ability to generate something new. It means the production by one or more people of ideas and inventions that are personal, original and meaningful. It is a talent, an aptitude. It occurs whenever a person says, does or makes something that is new" and "is present both in the thought and in the action" (p. ix). Howkins (2007) broadly paints economics as generally dealing "with the problem of how individuals and societies satisfy their wants, which are infinite, with resources which are finite" (p. ix). He brings his argument—creativity is big business—to hard economic systems. There are many different kinds of capital (infrastructure, physical, financial, human and intellectual) and the basic problem today is reconciling book value (an accountant's book of hard assets such as buildings) with market value and its inner driving force of human and intellectual capital.

Creative capital comes out of human capital in the form of innovative thinking, professional skills and collaboration. Howkins maintains that the growth of creativity is likely to outgrow all other economic areas in the global information infrastructure and, as such, investments in education,

research, and thinking increase creativity's value and effectiveness. Ideas and intellectual property are most valuable and "investments in education, research and thinking increase creativity's value and effectiveness as surely as do investments in other capital assets increase theirs" (p. 220). Economist and urban studies theorist Richard Florida has been arguing for creativity since his groundbreaking book *The Rise of the Creative Class* (2003) in which he pinpointed three supports of economically successful cities: talent, tolerance, and technology. Human talent is the raw material fueling the health of the creative economy, and through investments in education and technology, we can harness creative potential.

Leading economists all over the world have already called for the need for an increase in creative capital and its byproduct, innovation. Jeffrey Sachs (2010), Director of the Earth Institute at Columbia University and former Director of the Center for International Development at Harvard University, responds to the economic recession that began in 2008 by pointing to the need to focus on investment. In the *Financial Times*, Sachs writes, "We should be using the recent corrective boost in saving rates to promote long-term investments in physical and human capital as the proper way back to sustained growth." He goes on to state, "Long-term investment in physical and human capital as the proper way to sustained growth" (Sachs, 2010). Sachs' recovery plan for the economy demands "more education spending at secondary, vocational and bachelor-degree levels" (2010). One answer to this demand is Avenues: The World School, which opens in New York City for the 2012-2012 school year; it is a K-12 school that plans to establish campuses all over the world for an interconnected learning community. Benno Schmidt (2011), the Chairman of Avenues, believes, "The most important lessons Avenues can teach students are how to think creatively, how to analyze problems, how to innovate and how to work together both within and across cultures." This mission statement is also a definition of design thinking, of which information design plays an important role in cultivating creative capital.

There are many voices in the "new economy" discourse that has gained momentum in the past decade. One of which is the prominent economist Paul Romer (1993) who cunningly states, "Human history teaches us…that economic growth springs from better recipes, not just from more cooking" (p. 184). The economic historian Paul David agrees with Romer, in arguing "that intangible capital has become increasingly important as a driver in the United States economy over the last 100 years, and that this is largely embedded in investment geared toward the production and dissemination of information or improvements in human capital" (Hartley, 2005, p. 348). Human

capital can be cultivated through design thinking, which starts with education.

The United States government has underscored the importance of innovation through STEM education, which stands for science, technology, engineering and mathematics. Standardized tests across many industrialized countries place the United States far behind in these subject areas and, with a weakened economy, it makes sense to initiate public policy addressing this concern.

> President Obama has publically called attention to STEM: Everybody in this room [the White House auditorium] understands that our nation's success depends on strengthening America's role as the world's engine of discovery and innovation. And all the CEOs who are here today understand that their company's future depends on their ability to harness the creativity and dynamism and insight of a new generation. And that leadership tomorrow depends on how we educate our students today -- especially in science, technology, engineering and math We're going to win by offering the most innovative products. We're going to win by doing what we do best, which is harnessing the talents and ingenuity of our people to lead the world in new industries. That's how we can create millions of new jobs exporting more of our goods around the world. (The White House Office of the Press Secretary, September 16, 2010)

What is missing in Obama's statement is the means of offering innovative products and cultivating talent. The aspect of the STEM that renders it important on a global stage—beyond simply giving the United States a higher ranking on the scoreboard—is innovation, which is achieved through the divergent thinking that creativity induces. Rhode Island School of Design (RISD) President John Maeda (n.d.) believes that "innovation is born when art meets science" and that STEM should be amended into STEAM by inserting the letter A for art. Maeda (2010) believes that "adding art and design to science education would put a bit of humanity back into the innovation engine and lead to the most meaningful kind of progress." In his experience:

> Students at RISD don't think in terms of megabytes or equations; they think in terms of the warm, complex voice of a material like wood, or the way that glass finds its resting place differently on a cold winter day. Their hands, and sometimes faces, are literally covered with the materials they use to shape, angle, mutate, and translate their thoughts into handcrafted realities. Being an artist, I feel that art comes from the inexplicable urge to manifest a feeling, intent, or question as a specific, tangible experience. Artists do research with an open-mindedness and rigorous inquiry unseen in most other disciplines, except true science. They systematically and visually survey the world of ideas, objects, and experiences for inspiration by rummaging through it with their bare hands. (Maeda, 2010)

Maeda calls "this constant dialogue between eye, mind, and hand 'critical thinking—critical making.' It's an education in getting your hands dirty, in understanding why you made what you made, and owning the impact of the work in the world. It's what artists and designers do" (Maeda, 2010).

Design education needs to be considered as a real part of curricula in higher education, but at other educational levels as well.

An understanding of design education varies with each specified population. Secondary school students will be capable of understanding and creating more sophisticated projects than nursery school students. Likewise, post-secondary and continuing education students will typically be able to achieve a level of sophistication that is above the other populations. Since the capabilities and outcomes are different for different populations, the education will vary accordingly. Then there is the population of teachers and educators who themselves use data visualizations and are conscious of information design for their own lessons and curricula. The next chapter will closely examine continuing education's relationship with information design and will present a case study of an arts-oriented higher education institution's science classes. This investigation will illuminate the use of data visualizations by students and an instructor.

Chapter IV
INFORMATION DESIGN IN EDUCATION

Design thinking is gradually being introduced to the realm of education in small, localized doses and information design is one articulation of design thinking. Yet information design is virtually absent from education. The channel through which much information design is consciously being addressed is in the business world mostly in continuing education programs. Some business leaders have recognized the value of design thinking and, accordingly, have tapped business schools to incorporate creativity into curricula of MBA programs. Outside of business schools, one would expect higher education art institutions to have embraced information design. Yet it comes mostly as happenstance, as will be discussed in more depth in this chapter through a case study.

Data visualizations, due to their inherent statistical, quantitative-based content, are used heavily in the field of science. The case study in the following chapter considers the alignment of data visualizations and the quantitative nature of science education alongside the artistic nature of an arts-based higher education institution. Successful and effective data visualization involves a specific balance of art and science. This chapter reveals the demand for information design, the effective and ineffective uses of information design, and, finally, the problems and quandaries related to information design. Before delving onto the case study analyses, it is necessary to distinguish between effective and ineffective information design. The following table (Figure 2) highlights some properties of data visualizations that work and do not work. This will, however, be explored more thoroughly in the ineffective and effective uses of information design sections that follow.

SUCCESSFUL	UNSUCCESSFUL
1. Professional typeface (e.g., Gill Sans)	1. Background imagery
2. Balanced color palette	2. Trendy typeface (e.g., Papyrus)
3. Created with design program	3. Wide color palette
4. Integrity: Represents true data	4. Represents false, vague, or manipulated data
5. Interesting and meaningful	5. Moiré optical vibration
6. Useful and relevant	6. Order of data is ignored
6. Thin line strokes	7. Abundance of all-CAPS type
7. Order of data considered	8. Unnecessary boundary boxes
8. Muted, low-contrast grid	9. Thick line strokes, dark grid lines
	10. Drop Shadows (also: 3-D type)
	11. Created in Microsoft PowerPoint or Word
	12. Clip art
	13. Superfluous ornamentation
	14. Fake perspective/3-D displays

Figure 2. Select Characteristics of Successful and Unssuccessful Visualizations

The Demand for Information Design

Given the need for innovation and creativity in learning and working, certain institutions and groups show a desire to enhance their work and study with visual thinking and information design. The purpose of this section is to give insight into the high level of demand for information design in other fields to make a case for its increasing presence in K-16 education. This section examines the demand in the professional business world, higher education, society and the economy, and professional development. It also discusses the undeniable demand for successful information design in continuing education.

First, the origin of the demand for information design must be explored to provide context. As discussed in Chapter 3, there is a need for creativity to spur economic development. In order to cultivate creativity, design thinking should be applied to problem solving. An articulation of design thinking in the information age is information design that manifests as data visualizations. The creative economy functions best when innovation flourishes. Economist John Howkins (2007) argues that ideas drive capital gains, an insight attained by generally understanding economics as dealing with the problem of how individuals and societies satisfy their wants, which are infinite, with resources that are finite. From this macro-level perspective, one can begin to understand how innovative thinking and strategizing are articulations of solutions to problems. One important problem to solve is that of generating revenue at personal, corporate, and national levels. This understanding, which is also echoed by Richard Florida's ideas of the creative class, forms the basis for which design thinking becomes economically useful.

Demand in the Business World

Since financial gain and loss present a relatively direct measurement of effective design thinking and information design in business, demand increases for tools that provoke gains. Design thinking begets information design, which is gaining momentum through its use in corporate presentations. This section focuses on continuing education by examining a professional seminar conducted by Edward Tufte. It also looks at evidence of information design's application as a business product and business professionals' desire to learn more about data visualization.

Design thinking provides the opportunity to solve problems through research, brainstorming, analogous observation, and prototyping or testing. While engaging in design thinking, it is important to always take a human-oriented approach, which means to consider relevancy and intuition. The success of this type of approach can be best exemplified by the success of certain electronic products' interfaces that deliver ease of use through clarity: Apple computers, Google Blogger, and Facebook among many others. Through the internet we are able to access a seemingly infinite amount of information. At the dawn of World Wide Web popularity around the year 2000, there existed several search engines that were in fierce competition with one another such as Lycos, Excite, Hotbot and Dogpile. By 2004, the success of Google's IPO was a clear indication of its triumph over the online search industry. In the time since, Google has devised successful methods of gaining revenue through its innovative web page ranking and its AdSense advertising model which helped Google obtain a gross profit of $18.9 billion in 2010 (Yahoo Finance, 2011). Google has been so successful because of its use of design thinking's human-centered approach. In 2003 David Drummond, General Counsel at Google, pointed to exactly that in a talk given at Stanford Law School where he explained that "product decisions at Google are driven by optimizing for the user experience first and for revenue second. The folks at Google firmly believe that the better the user experience, the more easily money will follow" (Hornik, 2003). The information age necessitates adaptation to massive amounts of information and the success of Google underscores the importance of adapting.

Edward Tufte Continuing Education Seminar

Since there is a vast reservoir of data available to access via the internet, it is possible for everyday users to source information for use in a visualization. Similarly, companies have their own quantitative and qualitative data sets. In 2006 Edward Tufte published the second edition of *The*

Cognitive Style of PowerPoint in which he thoroughly and emphatically explains how presentations are ruined by the poor quality of design fostered by the ubiquitous Microsoft software application, PowerPoint. The problem, Tufte (2006b) argues, is that PowerPoint's forced template layouts and strict adherence to a hierarchical style corrupts statistical analysis and weakens verbal and spatial reasoning. Since 1993 Tufte has delivered seminars on information design that draw attendees from a variety of locations and occupations, who each hope to glean golden nuggets of advice from the legendary man *The New York Times* has called "the Leonardo Da Vinci of data." With more than three decades of teaching experience at Princeton University and Yale University, and with several books on information design published since 1983, Tufte has carved out a permanent place for himself as a master of the field.

In November 2010 Edward Tufte held a one-day seminar in New York City called "Presenting Data and Information." The focus of the seminar was as specific as its title: the presentation of information. Tufte's seminars are very popular; New York City had three dates in a row scheduled. The grand ballroom in which the event was held was filled with long tables and was brimming with approximately 400 attendees that were eager to learn about the effective communication of text and image. There were more men than women and the majority of the crowd was dressed in fashionable attire one step sharper than normal business professional wear; many men wore blue dress shirts paired with fitted jeans. While there were many marketing managers in attendance, other industries such as medicine were also represented. The heavy response of the business world reflects an overwhelming interest in information design and a desire to close the gap between pedestrian and professional graphic designers. Nevertheless, there is a disconnect between possibility and capacity. The technology can most likely be made available to business employees so that Adobe Illustrator, InDesign and Photoshop are within reach. Even non-designer software like Keynote and PowerPoint give a user the ability to exercise design thinking and creativity. Since these software programs offer this possibility, business people are looking for help in approaching these visual programs to convey information visually.

The course content consists of simple, practical guidelines as well as larger, more theoretical understandings. The effect is such that the non-designers are able to take away quite a bit of insight especially with regard to concrete specifics; the designers in the audience are able to take away much of the theory behind effective data visualization. There is also an entire body of information design language that serves to unify the audience. This consists of the many vocabulary words Tufte repeats

throughout the seminar: "Chartjunk" refers to extraneous elements in a table; "Chart-toonist" is someone who thinks they are creating an effective visualization by adding chartjunk and/or fancy effects and visual clutter; "Supergraphics" are intense, high-resolution images that take a bit of time to digest and get an audience thinking; and "Sparklines" are small, concentrated graphics usually embedded in a full context of words, numbers or images that hold huge amounts of data but are very simple constructions. By including his own data language in the seminar, Tufte is able to render it a unique event immune to replication.

Edward Tufte has sharpened his content so that it is very clearly and appropriately directed towards professionals looking to continue their education. The seminar is tailored for business professionals who want to improve their presentations and thus knowledge of information design. During the break periods in which Tufte makes himself available for questions and autographs, he asks each person the very same two questions, "Where do you work? What do you do?" This shows that the prioritized and relevant information in a brief discussion is the attendee's place of business and role within that business or organization. Tufte has also carefully selected the examples cited in his seminar so that they appear relevant to his target audience. For example, a discussion of "computer administrative debris" on digital menu interfaces is complemented by a baseball statistics interactive visualization meant to appeal to a competitive, male business executive who wishes to make winning points. Tufte discusses another example that is found in his book, *Beautiful Evidence*, that is a simple but elegant visualization of whisker marks (Figure 3) illustrating wins and losses of a baseball team (p. 55). Again, this example is compelling for his predominantly male audience, which is apparent by just looking around the room; nearly everyone's heads are buried in the book, examining the graphic with utmost concentration.

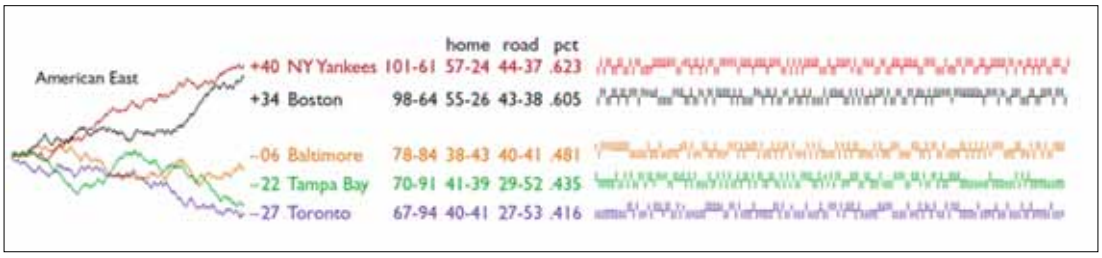

Figure 3. Edward Tufte's Whisker Marks for Baseball Statistics (2006a)

Tufte describes the whisker mark visualization as simple, straightforward, easy to see, luscious, complex, and all about the content. However, Tufte is careful not to tread on any egos and so

throughout the seminar, he comically refers to one's boss as "the admiral." This seminar is very much tailored to those who wish to improve their knowledge of information design. The demand for this type of event shows that financial gain is tied to the knowledge of information design as a continuation of education; a ticket to the event costs $380, which speaks to its value for business organizations.

The popularity of Tufte's seminars is highly suggestive of their value to business professionals. At the end of the seminar, with twenty minutes remaining, Tufte told the audience, "How to give a presentation. Finally. About time." The sounds of rustling papers and the clicking of pens and pencils filled the room as the attendees prepared to write down the "product" they had purchased: effective information design. When given six hours of valuable insight and information through case study and analysis by one of the most prominent leaders in the field, the attendees were only able to really take in ready-made advice clearly marked as such. Such a flippant attitude could be an indication of the audience's lack of awareness of the pervasiveness of information design in everyday life. Information design is then viewed as a limited skill intended strictly for presentations and not as an industry or field in itself. The main message Tufte is driving is that of the importance of information design for presentation's sake and not necessarily for the benefit of people outside the scope of the business world.

AIGA Continuing Education Seminar

There are other events and seminars in the design world that speak to the growing awareness of the value in the field of information design. The event "Data Visualization: Methods and Madness" was sponsored by AIGA (the professional organization for design) and Pentagram in conjunction with Parsons. The event was designed to explore how innovative thinking in data visualization brings with it new and more powerful mechanisms of perception and persuasion from the spoken perspectives of the professional, the academic, and the curator. Given that this is still a nascent field, this was one of the first formal events connected to information design, which could explain this fairly general series of talks aimed at an audience of graphic designers and media specialists. The terms "data visualization" and "information design" were used interchangeably, albeit the former was used more frequently; the panel of speakers did not have a solid answer on which term is the correct one when asked during question time. There is much to sort out in the field, but one thing is certain: there was a level of excitement and energy that left little doubt as to the demand for this type of event. Each of

the three speakers acknowledged several times throughout the evening that the great turn out for the event is evidence of the importance of this new industry. The host, Eddie Opara of Pentagram, called data visualization the "it" field.

The value of information design knowledge is also evident in the surge in examples of data visualizations as products in and of themselves. Frequently found in mass media publications that need to communicate data visually, visualizations are leaping off of the pages of magazines like *Wired* and *Scientific American* to become more than just added value. A company called Column Five Media specializes in creating and spreading effective data visualizations as part of a social media and public relations strategy. It works because there is demand to view and engage with visualizations by general consumers. Clients will thus pay for the design of content if it is used as a vehicle for advertising or promotions. This is a very new area of development so there are few case studies at this point in time, however there are select examples such as the below visualization (Figure 4) that was created at the start of tax season to promote awareness for TurboTax tax preparation software.

Figure 4. TurboTax Visualization (Column Five Media, 2011)

The designers of this exemplary visualization example took care to carry the TurboTax visual identity over into the design by using the color palette used in packaging: blue, red, white, and gray. The proportions of the colors are also analogous to each other. Column Five Media was able to use design to bring humor to the otherwise dry subject of taxation. Not quite product placement, but equally as influential, this graphic is a useful way to engage with consumers on a deeper level than a superficial internet advertisement. The direct implications of this type of use of information design are commercial, however due to the nature of promotional pieces, the TurboTax visualization will receive

many impressions and thus have a far reaching impact on the general public. Moreover, effective—which in this case is to say well designed and willingly received by the target audience—visualizations like this call attention to the practical aspects and commercial viability of design. Through this channel, demand for information design in non-advertising contexts is likely to increase.

Demand in Higher Education

The education field is starting to respond to the problem of information inundation by indirectly addressing information design. If the intention is to communicate information more effectively, data visualizations achieve that end. Therefore, to deliver clear communication, the development of information design can be an asset for information-heavy courses such as science classes at the higher education level. Scientific learning is sometimes dependent on effective visualizations. Thus, the more effective the visualizations used in classes, the better the learning experience since the scientific concepts are communicated with clarity and agency. There are two main areas in which the demand is apparent: information design degree programs and within individual classes.

Information Design degree programs and majors are rare, but they do exist to some extent. Kent State University offers a Bachelor's of Science in Information Design through their journalism school. Notably, it is a Bachelor's of Science, which addresses much of the content inherent in information design that is composed of statistics. Starting in the second year of study, students must take two upper level courses that relate directly to information design; one of the courses is Visual Design for Media: Advanced and Information Graphics. Another requirement for the degree is to take one of these science-oriented courses: Political Methods, Quantitative Methods in Psychology I, or Data Analysis. Students have a wide variety of choices to fulfill 6-7 credit hours in basic sciences, 3 credit hours in mathematics, and 6 hours in social science ("Information design: About," 2009). By offering a core curriculum of a wide variety of subjects from art history to politics to psychology, Kent State University seemingly provides a successful course of study for a solid foundation in understanding information design and its content. Missing, however, are design and studio fine arts courses. Kent State University states that graduates of this program can find employment as page designers or copy editors at newspapers, magazines, and online publications ("Information design: About," 2009). Given the societal shift away from printed media, one should question the true vocational value of this program.

The lack of information design programs is especially noticeable in higher education. Currently, it seems that information design is embedded in graphic design and communication arts programs usually within courses, however sometimes as its own course. The Rhode Island School of Design (RISD) offers a graphic design major with a variety of electives; one of which is the 6-credit "Making Meaning" that "introduces techniques of image making in relation to ways of analyzing and creating meaning in graphic and typographic messages. Aspects of image making, information design, visual narrative and semiotics will be explored in the context of practice and theory." Likewise, Parsons has an advanced course within their undergraduate Communications Design program called "Topics: Information Design" in which "students will compliment the historic and theoretical readings with their own research, and will develop a larger independent project along their own areas of interest. Emphasis is on critical thinking, iterative design methodology and synthesis of research, design production and presentation" ("Topics: Information design," 2010). It is notable that the course partially consists of reading and research in addition to design projects. The School of Visual Arts (SVA) offers a diverse undergraduate program for graphic design majors that, like the aforementioned schools, offers a high level course in information design called "Information Graphics I: How to Present Information Visually" that aims to deliver a "comprehensive understanding of the field of information design, and the skills needed to create solutions of the highest caliber. In our information-driven age, design directors are looking for designers who can bring an understanding of information design to their department. It can also be a complete career in its own right" ("SVA courses–information graphics," 2011). The acknowledgement by one of the world's top art schools that information design can be a career in and of itself is of critical importance. It provides weight to the argument for attention to, and an increase in, information design education. However, none of these programs directly address the field of science thereby leaving it to the student to design an independent study that relates to science or seek out science courses as electives.

Another venue in which to find information design in higher education is within actual science classes. In conducting observations and interviews in science classes at Art Education University[1], I discovered that there is a substantial presence of information design in day-to-day assigned readings, lectures and in-class projects. In an observed Science and Society class on energy, I noticed that nearly everything discussed needed a visualization for comprehension. For example, understanding nuclear energy requires knowledge of processes that are best communicated through

[1] Fictitious name.

a diagram showing the pathway of uranium processing, enrichment, thermal reaction, and waste storage.

Other topics that necessitated visualizations were hydrogen energy and CO_2 carbon capture and storage. The assigned readings for this class consisted of several articles expertly culled from a variety of sources by Professor Brown[2] that included *Scientific American*, *Science*, *The Economist* and *Nature*. These publications provided many of the visualizations used in the lecture slide presentation, but were by no means all of them; some were obtained from other articles, journals, or texts and some were original creations by Professor Brown. This demonstrates that science educators demand effective data visualizations to use in their student lectures. It also brings to light the relatively unchartered territory of professional development courses or programs in information design for higher education professors, which will be discussed in more detail in a later part of this section. One problem with relying on publications to provide effective visualizations is that some of the more detailed, data-heavy visualizations are poorly designed. Professor Brown points out, for example, that the graphs in the 2007 Intergovernmental Panel on Climate Change (IPCC) report, which is known as the world's most authoritative scientific account of the scale of global warming, are not as well-designed as they could be. On the other hand, Professor Brown reasons, magazines like *Wired* have many impressive visualizations, but they may not always be completely reliable science (interview, January 11, 2011).

Another area of demand related to lectures is the need for an application that is design-oriented and organizes information very well; rather than Microsoft PowerPoint, Professor Brown uses Apple's Keynote software, which is more intuitive and offers graphically intellectual grid system-style layouts rather than bulleted, hierarchical lists. The means to create content is just as important as the content itself.

Graduate higher education is friendlier to information design than other education levels mostly because of the self-directed nature of Master's programs. Stanford University's Institute of Design (known as the d.school) is a university-wide hub for innovation where students from engineering, the arts, medicine, education, law and the social sciences come to take classes and develop projects. The d.school brings students and faculty from radically different backgrounds together to develop innovative, human-centered solutions to real-world challenges. Additionally, the d.school offers many workshops and programs for working professionals to continue their education. The d.school also houses the K-12 Lab which brings design thinking to elementary and high school

[2] Pseudonym.

students through the development of curricula, teacher workshops, and distance learning. The K-12 Lab works to help students, teachers and schools foster creativity so as to develop the youngest generation of innovators ("Stanford," 2010). Stanford's pedagogical approach is non-traditional, however its method is in agreement with the complexity of the global economy and the a-la-carte way of acquiring knowledge the information age.

The RISD Graphic Design Master's program offers independent study opportunities through which information design can be explored. In light of the budding state of information design, Parsons has reacted to the development of design thinking by devising a new Master's of Arts program in Design Studies, which is slated to launch in 2012. Like its undergraduate course in information design, Parsons has integrated historical, theoretical, philosophical, and social issues into the Design Studies graduate program. Additionally, students have the option of taking courses from other disciplines offered at The New School so that it is possible to supplement one's course of study with up to six credits of science, math, or statistics classes ("Topics: Information design," 2010). There is growing interest in information design, however it is mostly embedded within higher education programs. Parsons' new Master's program in Design Studies sheds light on the importance of critical thinking and it is possible that it will have a trickle-down, ripple effect on undergraduate and secondary school levels.

The science industry in general exhibits demand for information design. *Science* magazine holds an annual competition called the Visualization Challenge in which researchers submit entries created in the previous year that are judged by a panel of experts. The year 2011 marks the 8th year of the challenge and Science received 111 entries from 63 countries. The existence of such a competition underscores the importance of design within the scientific community. The driving reason for holding the competition is because "researchers are generating mind-boggling volumes of data at exponentially increasing rates. The ability to process that information and display it in ways that enhance understanding is an increasingly important aspect of the way scientists communicate with each other and—especially—with students and the general public" (Nesbit & Norman, 2011, p. 847). The demand for information design cannot be stated more clearly by experts in the science field.

Society and Economic Demand

There is little doubt as to the relevance of creativity and innovation to a productive economy and healthy society. The United States government has reacted to the need for innovation by calling

attention to the need for improvement to science, technology, engineering, and mathematics (STEM) education so as to achieve a higher ranking than other countries in standardized tests.

In light of the low scores the United States has in math and science in the global community, there is a recent increase in policy efforts aimed at supporting education in the areas across multiple educational levels, elementary school through secondary education. One such effort is the launch of Change the Equation, a non-profit that brings together 100+ CEOs from the nation's largest companies dedicated to mobilizing the business community to improve the quality of STEM education in the United States (The White House, 2010). Change the Equation falls under a broader campaign the United States government is currently implementing called "Educate to Innovate," which aims to improve the participation and performance of America's students in STEM (The White House, 2010).

This campaign brings together the private and public sectors to form relationships between the business world and schools. For example, the STEM Video Game Challenge presents a competition for a winning student (grade 5-8) living in a high-poverty area to design a videogame for $50,000; it is sponsored by The Entertainment Software Association, Microsoft, and AMD in partnership with the American Library Association, the Joan Ganz Cooney Center at Sesame Workshop, the Boys and Girls Clubs of America, and E-Line Media (The White House Press Release, 2010). President Obama maintains:

> Everybody in this room [The White House auditorium] understands that our nation's success depends on strengthening America's role as the world's engine of discovery and innovation. And all the CEOs who are here today understand that their company's future depends on their ability to harness the creativity and dynamism and insight of a new generation. And that leadership tomorrow depends on how we educate our students today – especially in science, technology, engineering and math. We're going to win by offering the most innovative products. We're going to win by doing what we do best, which is harnessing the talents and ingenuity of our people to lead the world in new industries. That's how we can create millions of new jobs exporting more of our goods around the world. (The White House Press Release, 2010)

Recognizing the value of creativity is a good step forward for the government. However, it is somewhat detached from creativity as the agent to harness talent. Creative prowess is also about strengthening society and individual self worth, which is not mentioned by President Obama. Establishing relationships with businesses to sponsor K-12 education initiatives like contests engages the natural competitive inclination of a capitalist society. Change the Equation is a group of CEOs from the largest businesses in the country. Who is to say that CEOs know what is good to teach in

classrooms and how it is taught? And why are CEOs from the largest companies better than those from the smallest companies? It can be argued that because the classroom is a small population, CEOs from small businesses would be better poised in this role. Injecting competition into classrooms betrays what is necessary to design thinking: cooperation.

An alternative to the well-intentioned, but misguided, STEM initiative is that of STEAM, which stands for science, technology, education, art, and mathematics. Headed by RISD President John Maeda, STEAM calls attention to a necessary ingredient to move forward. Maeda (2010) strongly advocates for art to be understood as vital to innovation and believes that "adding art and design to science education would put a bit of humanity back into the innovation engine and lead to the most meaningful kind of progress." Tim Brown (2009), of the creative consultancy firm IDEO, agrees that a human-centered approach is important and that it houses the elements of design thinking: field observations, prototyping and visual storytelling (p. 148). Pointing to education policy, and more specifically at President Obama and the Whitehouse, Maeda stresses the need to include art in education:

> When policymakers today talk about education and reform, it's all about the STEM subjects. It's about convergent thinking – problem solving by breaking it down. Instead, a divergent thinker takes an idea and looks to expand it, and to find new diverse ways to connect it," said RISD President John Maeda. "You need both to create balance: combining STEM with the Arts to get STEAM. In the past 20 years, we've focused too much on technology innovation. Art and design humanize those developments, and fuel true innovation, which ultimately leads to economic recovery and leadership. The National Science Foundation is attuned to the need for innovation, and through these continued collaborations we will advance STEM to STEAM in the United States of America. (Maeda, 2010)

In January 2011 RISD hosted a workshop, sponsored by the National Science Foundation, called Bridging STEM to STEAM: Developing New Frameworks for Art-Science-Design Pedagogy. The workshop brought together 60 leaders from the fields of science, creative IT, engineering, art and design, mathematics and education research to strategize about innovative ways to fuse these fields and teach new approaches to creative problem solving.

The economy demands creativity through innovation and design thinking is a path to creativity. John Howkins (2007), an expert in creative industry, argues that the growth of creativity is likely to outgrow all other economic areas in the global information infrastructure and, as such, investments in education, research, and thinking increase creativity's value and effectiveness. A first step toward instituting design thinking into curricula, and perhaps a class in its own right, is recognizing its value at the policy level. That is why Rhode Island Congressman James Langevin

introduced The Stem to Steam Resolution into the United States House of Representatives in September 2010. In his House remarks to the 111th Congress, Langevin made it clear that art should be a policy priority:

> In order to strengthen the pipeline of future artists and designers, we must add STEAM to legislation that shapes the future of our education system, especially the Elementary and Secondary Education Act and the America Competes Act. Congress must also encourage institutions of higher education to incorporate art and design into their STEM curricula. Art and design contribute real solutions to our everyday lives, distinguish America's products in a global marketplace, and create opportunity for economic growth in the United States. Artists and designers can effectively communicate complex data and scientific information to multiple stakeholders and broad audiences. The tools and methods they use also offer new models for creative problem-solving and interdisciplinary partnerships in our growing 21st Century economy. (Langevin, 2010)

Langevin (2010) also proposed creating a STEM to STEAM council that would bring together artists, designers, education and business leaders, and federal agencies to facilitate a comprehensive approach to incorporate art and design into Federal STEM programs. While the proposal did not gain the appropriate traction in Congress, Langevin's resolution put the issue of art and design education on the record not just for higher education, but for elementary and secondary education as well.

Demand Through Professional Development

As the final and ongoing level of learning, continuing education realizes the importance of information design so as to render it an asset in professional development across different disciplines. A key example is the diversity of professions represented at Edward Tufte's seminars on presenting information. Communicating information is a necessary component of nearly every profession and the desire to learn how to communicate more effectively is an indication of the general embrace of information design. The same is true in the case of the Data Visualization: Methods and Madness event at Parsons that was quickly sold out. Tufte's seminar, which has existed for many years, has a strong reputation and travels to major cities across the United States. However, conferences and events that are centered on information design are still rare, which speaks to the nascent state of the field. There is a void in the area of professional development in information design. It is therefore important to consider the ways in which information design could benefit professionals and educators.

Data Visualization: Methods and Madness (January 12, 2011) was an event that was the

first of its kind for AIGA and Parsons. Never before had there been an event centered on information design sponsored by these organizations. There were three guest speakers: Kate Carmody, a curatorial assistant in the Architecture and Design department at The Museum of Modern Art; Laura Kurgan, Co-Director of the Spatial Information Design Lab (SIDL) in the Graduate School of Architecture, Planning and Preservation at Columbia University; and Lisa Strausfeld, a partner at the design firm Pentagram. The event took place in the large Tishman auditorium at Parsons which was buzzing with energy. Alternative rock music lightly played in the background as the event began. The speakers were astounded by the energy and audience turnout, which amounted to approximately 450 people. Attendees were interested in learning about effective information design through case studies. Noticeably, the demography of the audience was rather homogenous and consisted mostly of men and women in their 20s or 30s; there were no more than ten attendees over the age of 50. Moreover, the event was introduced by Pentagram Partner Eddie Opara whose first word to the audience was the name of the Twitter hash tag for the event. The young demographic reflects the young state of information design as an industry.

The content of the event consisted of case studies presented by each of the three speakers mostly from their bodies of work. One of Lisa Strausfeld's earlier examples was an interactive design from 1999 that gave a digital platform for users to experience sports that do not lend themselves well to television: car racing and sailing. The project consisted of assemblage of various real-time statistics such as speed and position of each car in a digital interface. Laura Kurgan delivered a study of her Million Dollar Blocks Project (2010) in which hard quantitative data was re-imagined into an interactive visualization of mapped out addresses of formerly incarcerated individuals; color is used to emphasize the cost of their incarceration. This represents an example of a non-profit funded project, which tends to be the norm. However, there are the beginnings of for-profit funding for data visualizations by select corporations including General Electric.

Outside of continuing education there exist few teacher professional development programs on information design, however that does not mean there is no demand for them. Professor Brown was interested in ways to make finding information more intuitive through design. Upon viewing the appendix (Figure 5) of David McCandless' information design book, *The Visual Miscellaneum*, he responded, "I could much more easily locate something from an index if I don't remember the exact name, so seeing a representation of it could help immensely…that is the way my brain works. The innovation of slipping figures into the index is great. If I were to write a textbook, it would feature

that. A lot of textbooks are so utilitarian." The demand for information design does not stop at content, but rather the structure of sources science educators use to inform their lessons. Moreover, many scientists think like artists and so developing content that fits with their cognitive orientation would be extremely useful for further professional development.

Figure 5. Appendix from *The Visual Miscellaneum* (McCandless, 2009)

Ineffective Information Design

Much of the demand for information design comes from its new utility, but demand also stems from the existence of ineffective information design. Data visualizations can be unsuccessful for many reasons and this section aims to develop an understanding of how through an examination of failed design and poor utilization of the data. First, the shortcomings of information design in the business professional world will be examined to provide context for its failure in education. Since students have the power to create visualizations themselves, opportunities to do so will be explored from multiple education levels from within the classroom and then from within the institution as a whole. Lastly, one area that has not been covered is that of information design's role in forming a school's representation of itself through branding, and marketing or promotional materials.

There are several general, obvious signs of ineffective data visualizations that are attributed to poor design. Reverse typography (white on black) should be avoided since it is difficult for the eye to read because the black negative space becomes the immediate focus for the eye. Adding ornamental baubles like exaggerated drop shadows and three-dimensional text should be avoided, as they are simply a ploy to make information stand up and shout its presence as a way of overcoming the noise of the background or weakness of data. A color palette should be as minimal and pared down as

possible so as to let the data breathe, albeit without compromising its credibility. Using a photograph as a background detracts from the foreground (the data) in a forceful way, especially if there is high opacity.

Unfortunately, there exists an abundance of unsuccessful data visualizations. Such visualizations are and will always be present, however the frequency could decline significantly over a short period of time with continuing education seminars and programs. Edward Tufte, one of the most critical voices against poor information design, has a simple way of explaining ineffective information design; he has humorously created the concept of the "chartoonist" which refers to someone who acts like a cartoonist in designing charts or other representations of information. A cartoonist creates a simplified or exaggerated form or interpretation of a subject; the chartoonist's subject is data. According to Tufte (1990), "too many data presentations, alas, seek to attract and divert attention by means of display apparatus and ornament. Chartjunk has come to corrupt all sorts of information exhibits and computer interfaces" (p. 33). However, a designer must be careful not to simplify too much since manipulation of data can draw attention to one specific aspect of it or, worse, obscure the data. The last thing a designer or scientist would want is to be professionally categorized as a cartoonist.

Tufte's related term "chartjunk" refers to extraneous details that obscure or handicap a visualization. For example, a table consisting of rainbow striped rows that distract and offer no useful visual organizational role; or elements like color or gradient-color backgrounds, dark grid lines, and boundary box mania. Other, more detailed, chartjunk includes extraneous parentheses or extra spacing around en-dashes because they do not contribute to an understanding the data.

Another attribute of effective information design is the choice of what data to present and what data to leave out. Minimal is not necessary better, argues Tufte. In his seminar Tufte (2010) professed, "People read lots of table data all of the time…80 million people a day read sports pages." The general public, then, is not a stranger to processing numbers. Tufte also condemned the average amount of numbers on a typical PowerPoint slide —12—as too few with the quip that the world is a lot more complicated than 12 numbers. A key takeaway from this point is that people should not be afraid to present a hefty amount of numerical data as long as it is presented with clarity and transparency. If one finds that there is clutter and confusion in their visualization, the solution is to fix the design rather than eliminate data.

Ineffective Information Design in Business Organizations

There is an abundance of poor data visualization design and organization in the science field. One of the leading scientific agencies, The Centers for Disease Control And Prevention (CDC), generates a plethora of visualizations due to the quantitative nature of their expansive work. The CDC's visualization below (Figure 6) attempts to show expenses related to sickle cell disease in children and is a key example of ineffective design.

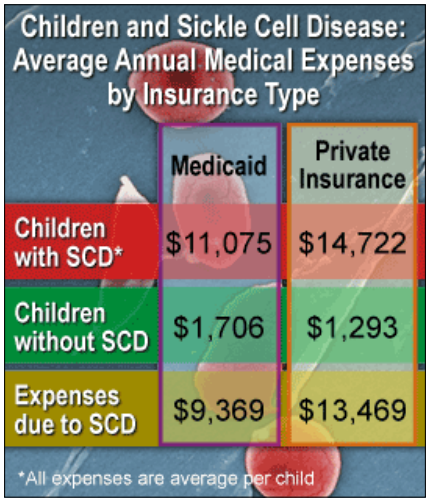

Figure 6. CDC Visualization "Children and Sickle Cell Disease" (CDC, 2010)

This visualization is from the CDC's web site where a general audience, medical professionals, and scientific researchers can easily access the information. The most obvious problem has to do with the dizzying color palette: there are ten garish colors found in eleven cells, which is unnecessary for visual comprehension given the small size of the table. Nearly all of the colors of the rainbow are represented in this small graphic; color is being used as shameless ornamentation. Vivid red and green are too optically competitive; they are complementary colors which, when paired, make for an offensive optical assault. The typeface is another major problem. Reversed white type is more difficult to read than a dark color on a light background; and moreover, the chart arbitrarily mixes white and black type. The typeface is Geneva, which is a clunky copy of the carefully crafted and respected Helvetica. Boundary boxes are unnecessary chartjunk that only serve to add an additional layer of clutter, which is made all the worse by the vertical boxes that have a thick line stroke in different colors. Additionally, the photo in the background is distracting noise that is disrespectful of the data. Since there are only three rows, it is not so difficult for viewers to discern between the cells that color needs to be used for organization. The visualization below (Figure 7) reimagines the original CDC

visualization by eliminating the optical clutter:

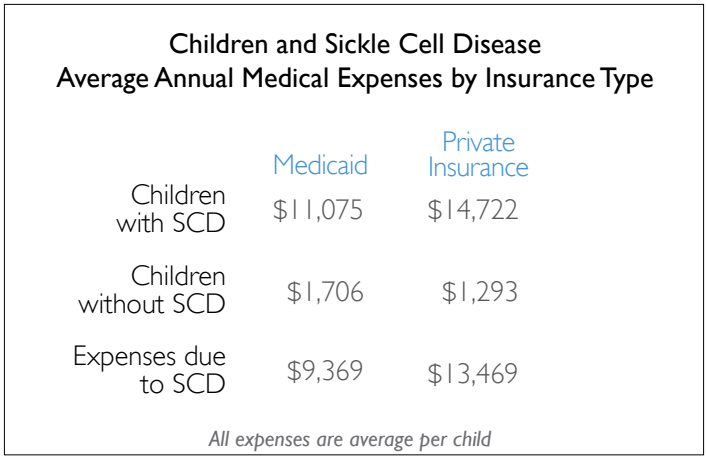

Figure 7. CDC Visualization Reimagined "Children and Sickle Cell Disease"

The strong desire for imagery evident in the CDC example (color and photograph) may speak to scientists' desire to inject creativity, design, and possibly even story into their work; this is also more broadly indicative of demand for information design in the science field. Unfortunately, the CDC is a very large scientific organization with a high data output so these types of graphics are rampant throughout CDC research and communication. An abundance of boundary boxes is a common sign of ineffective data visualization. It reflects the scientist's desire to convey the organization and rigidity that is supposed to accompany scientific facts and figures. The over-emphasis of the boundary boxes in the CDC visualization could be a scientist's compensation for the inappropriate presence of a background photograph.

Typography is another area in which visualizations frequently go wrong. Many of the gratis internet sans serif typefaces (Arial, Verdana, Geneva) are not crafted with the same quality as that of purchased typefaces such as Helvetica, Gill Sans, and Akzidenz-Grotesk. Moreover, many non-designers do not realize that the display of information on a screen necessitates different type treatment than printed information because of the precision inked and printed material has over the limited resolution of digital screens. Typically, a large amount of data needs to be broken down into charts, tables, graphs, etc. to understand the findings rather than through reading paragraphs of text. Therefore, it is in the creator's best interest to use typefaces that are legible in small sizes. Gill Sans is one of Edward Tufte's favorites because it appears sturdier and more readable due to the increased white space made possible by the small x-height and reduced size (2006, p. 51).

Ineffective Information Design in Science Classes

Due to their inherent statistical orientation, science classes at the higher education level are filled with information design, however much of it is ineffective. Either the teacher or the students can create visualizations, but the majority of visualizations enter the classroom through lectures or presentations. Since nearly every concept requires some kind of visual representation for understanding, there is an abundance of graphics used in classroom instruction that are culled from a variety of reputable sources such as academic journals and studies conducted by research organizations. The problem is that some of the very reputable sources are not purveyors of effective information design, which does injustice to their findings and subsequent student learning. Yet equally detrimental are the impressively designed visualizations found in popular magazines like Wired that may not have used completely reliable scientific data or have distorted the data.

Visualizations as Teaching and Learning Tools

Science classes at Art Education University are buffered by their artistic setting. Accordingly, Professor Brown has an awareness of effective design that enables him to recognize some ineffective data visualizations. However, sometimes a topic is vital to class learning so that he must reluctantly use these visualizations. According to Brown, "Well-composed visualizations can certainly help. Bad visualizations can hinder and can make you come to very wrong conclusions" (interview, January 11, 2011).

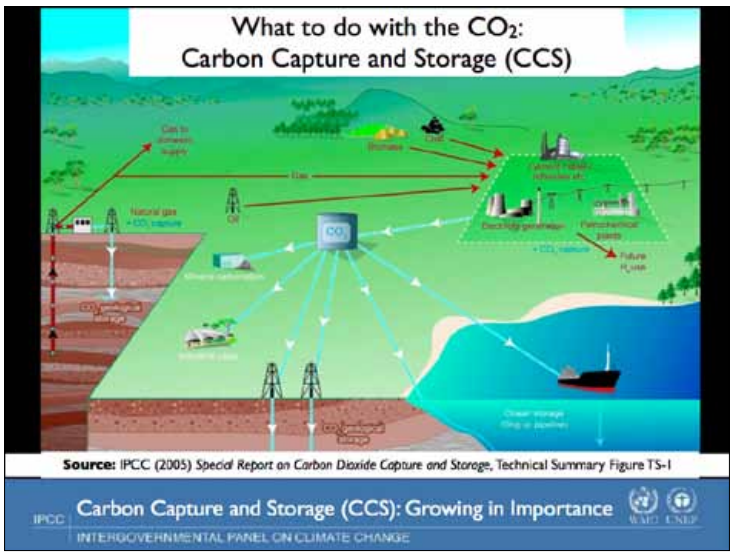

Figure 8. IPCC Carbon Capture and Storage Visualization (IPCC, 2005)

Professor Brown recognized the very poor design of this visualization (Figure 8) that comes from the Intergovernmental Panel on Climate Change (IPCC), a scientific research body that is the most reputable source of climate change data. He used the visualization within a class slide presentation. Despite the high reputation, the visualization the IPCC produced looks as though it was lifted from an old videogame because of its various kitschy miniature icons and pixilated gradient sporting too many gradations. The typeface is shoddy and is difficult to read both because of its poor construction and because the type colors blend into the background. It was not a good design decision to make the type white since it is difficult for the eye to isolate the text from the busy background it sits within; this is especially apparent in the text over the soil area. Yet there is appeal in this visualization, but it is certainly not design; rather, it is the element of story. An overview of multiple scientific processes in one picture is appealing to scientists since it brings together interrelated concepts in one graphic. Professor Brown found a personal element of story in the image that relates to his family's involvement in the oil industry; he thus brings added value to the class discussion despite the visualization's deficiencies (interview, January 11, 2011).

Another instance of ineffective information design as used by a teacher relates to climate biomes. Professor Brown used two different visualizations (Figure 9) that each represents the earth's biomes through the variables of temperature and precipitation.

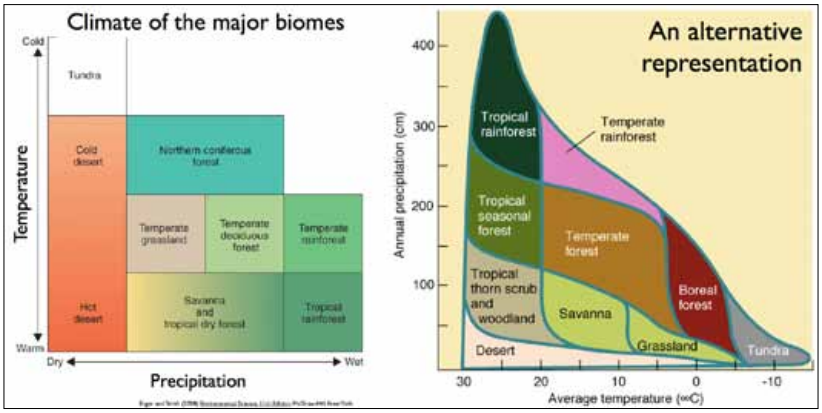

Figure 9. Biome Visualizations (class observations, February 16, 2011)

These visualizations attempt to convey the relation of biomes to one another, however the one on the left has maintained a strict, grid-like structure whereas the one on the right realizes the variance in each biome through soft, tapered forms. There are no firm boundaries between biomes so the left visualization presents a greater degree of error. While the visualization on the right conveys the

relationships between biomes more accurately, it also happens to be saddled with poor design: stroked outlines are too thick and are blue, not a neutral color; there are too many colors not in harmony; the typeface is clunky; and the type color is not consistent. The task of the science educator is to decide which visualizations to use in a presentation. Professor Brown shows both in addition to a climate world map indicating the geographical distribution of biomes. According to Brown, the selection of visualizations to bring into the class is a long process where important figures are whittled down over the years, which makes finding effective information design an ongoing endeavor (interview, January 11, 2011).

Visualizations in Active Student Learning

There are opportunities to integrate information design into science course content, however it is up to the teacher to provide the opportunity and it is up to the students to provide participation. For example, in the undergraduate course Science and Society at Art Education University, students were challenged to create and/or use visualizations. An in-class exercise involved assembling groups—that were named in the previous week's class—that were assigned one type of energy (e.g., wind, biofuels, nuclear) to read about before conveying their findings to the class in a short 7-10 minute presentation. It was a requirement that each group include a visualization in their presentation, however most groups relied on examples from the articles they read rather than creating their own. Much of the discussion in the nuclear energy group served to arrive at an understanding of the topic, which ultimately came from interpreting one of the visualizations from an article. It is not just the educator who needs visualizations, but the student as well; this was made clear by the groups' enthusiastic embrace of and reliance on visualizations. The students were not strongly encouraged to come up with original data visualizations. Subsequently, when given the option to use the given visuals from the articles, nearly all of the groups used those rather than create anything themselves. One student in the wind energy group had brought a diagram drawing of a turbine to class, but that was the extent of out-of-class visualization work. This begs the question of what would happen if the groups were required to create an original visualization. There is the possibility that they would mistakenly misinterpret the data, which could be detrimental to the whole class. Perhaps creating a visualization could be a take-home assignment instead so that students have time and space in which to put effort into their designs.

Higher Education Institutions and their Failure to Act as Incubators

Higher education institutions, both liberal arts and fine arts types, are not serving as incubators for information design despite their ripe and ready positions. Students are given the opportunity to create visualizations, but this practice is not being integrated into curricula. Despite it being an art school, Art Education University's students in science classes are reluctant to draw and are self-professed " bad drawers." For one of the activities in an ecology class groups had to draw climate biomes. Students assembled into groups and started with a large drawing board, piece of paper, and markers. The task was to add one specific element (e.g., landscape, animals, food webs, threats) to the picture before passing the board to the next group in a clockwise fashion. Interestingly, many of the drawings were symbolic and representational rather than realistic. For example, one student had drawn a fur hat in corner representing Russia for taiga biome. This is indicative of higher order thinking and conceptualism. Perhaps the symbolism was used so pervasively because students wanted to deliberately maintain college-level thinking; this then affected their classroom behavior.

Conversely, students may have simply been uninterested in expending creative energy on the activity. Humor permeated each group's output so that there was abundance of inside jokes, political satire and comical characters. There was a sense of competition: the students attempted to out-laugh one another. Notably, the students were okay with guessing and being wrong. They did not labor over realistic looking drawings so that when complete, each biome drawing looked messy. Vibrant energy is legible in the drawing, which shows that the process, or act, of drawing various components of the biome was the evidence of student learning and not the finished product. Overall, it was evident that students wanted to create narratives which led to not so straightforward drawings; skill level did not negatively affect the dynamic. Thus, an argument could be fashioned to support creative problem-solving assignments that incorporate student-created data visualizations so as to increase the effectiveness of information design in higher education.

Ineffective Information Design in Continuing Education

The success of Edward Tufte's seminars over many years is an indication of the burgeoning problem of ineffective information design. Microsoft PowerPoint is the culprit behind much of it; Tufte has written an entire book on the subject. The program appeals to business executives because it offers "power" to users who wish to make points. The problem, alleges Tufte, is that PowerPoint forces a hierarchy of simplicity onto the user, which can distort data that should not be extrapolated

into bullet points. As design becomes more attainable through the internet's sharing of ideas and the development of programs like those in Adobe Creative Suite, many non-designers are becoming aware of successful design through consumer products (e.g., Apple iphone, Facebook interface, Target's brand identity, etc.). As a result, poor design stands out and is being rejected by savvy professionals, hence the success of Edward Tufte's seminars.

There are two types of ineffective information design for continuing education to address: structural and elemental. Structural refers to the content of information displayed and the type of visualization that is being used to present the information. Elemental deals with the specific aspects of design within a visualization such as line and color. The CDC visualization (Figure 6) that appeared in the section on Ineffective Information Design in Business Organizations has the structural fault of using a table when the amount of data is not enough to warrant this type of representation. This would be akin to a writing outline that uses the Roman numeral "I" with just an "A" and not a "B" under the heading and without subsequent Roman numerals II, III, etc. Another example of a structural fault is the use of a bar chart when there are more words than numbers in the data. Elemental faults with the CDC visualization were listed in the previous section and include more aesthetic components like color choice and background imagery. This faulty example is not an isolated case; visualizations like this exist throughout the scientific community. Continuing education programs in information design would be valuable for scientific researchers, yet there remains a void for the Edward Tufte of scientists.

Ineffective Information Design in School Branding

School branding includes all of the visual information related to how a school presents itself publically and privately to the world. This includes elements like a school's name, logo, visual identity, web site design and structure, layout of school forms, etc. It seems that the many charter schools that are overtaking cities are reaping success from their cohesive branding and visual identity, which exists because of the newness of the school. However, not every charter school has a solid brand identity. Public schools, which have been around for much longer than charters, have to contend with the problem of having to work with numbers for names, disconnected staff, loose mission statements, and a general lack of visual identity. It is easier to institute positive change when starting anew as opposed to reforming an existing organization.

Many New York City public schools are impaired by ineffective information design.

Numbers being used as names is a big problem. The reason why schools have numbers as their name is because the city government allocated numbers as a way of dealing with the vast number of schools. Although the schools have names as well as numbers, they are mostly known by their numbers. Interbrand, one of the world's foremost research and branding firms, argues, "A significant downside to numbers is that they are difficult to own" so that "like acronyms or new words, numbers don't immediately express their proposition or product, with the result that greater effort, time or expenditure may be required to build associations into the brand" (Grannell, 2005). The addition of a historical figure's name to the number without any strong connection between mission statement and the figure does nothing to help a school stand strong as an organization. "Numbers can be differentiating within a sector [i.e., a school system], but as a consequence this means that the opportunity to use them as brand names is limited. It's a fair bet that there can only be one numerical brand within the mobile telecommunications market; and only one foodservice company with a number as its name." (Grannell, 2005). Since solid branding is an essential quality for a successful school, public schools seem destined for obscurity simply because of the government's arbitrary numerical naming system.

Many of the elementary schools in New York City are identified by a number and a name, which is usually that of a historical figure, but the name can also be a neighborhood or a specialization. For example: P.S. 63 William McKinley, P.S. 212 Midtown West, and P.S. 506 School of Journalism and Technology. Usually there is some kind of relationship between the named figure and the school philosophy. However P.S. 63 contains no references to William McKinley, the 25th United States President, neither in the mission statement on their web site nor in the expanded mission statement from the principal on greatschools.org. This statement is from P.S. 63's web site:

> Our staff recognizes that all children learn differently and it's our job to build on their strengths and determine how to best reach each student. At P.S. 63, we encourage students to become active participants in their education and school-wide community. We believe that this philosophy will guide students on their path to becoming lifelong learners. ("P.S. 63," 2011)

Indeed this is a broad statement hardly unique to this specific school. On the Great Schools web site, however, the Principal has elaborated on more specific details that make P.S. 63 a good school. Some examples include these extractions: "the hidden gem of the Lower East Side…small class sizes… every teacher knows every child…the Everyday Math Program uses real-life situations, students' prior knowledge, and games that re-create realistic math experiences…Monthly School Assemblies…

School jobs- Students take ownership within the School community…This school is best known for its individual student instruction…The school uses the following instructional model: Core Knowledge" ("The principal's view," 2011). Additional features like the "3 Ps in a Pod" curricular meetings with the Principal, Parent Coordinator and Parents" further enforces the school's uniqueness ("The principal's view," 2011). The overall effect of this cohesion is the building of a strong school community where everyone supports the school.

P.S. 63's strong mission statement from Great Schools is not found on the school's own web site. In fact, the school web site (Figure 10) is a great example of ineffective information design in the realm of school branding.

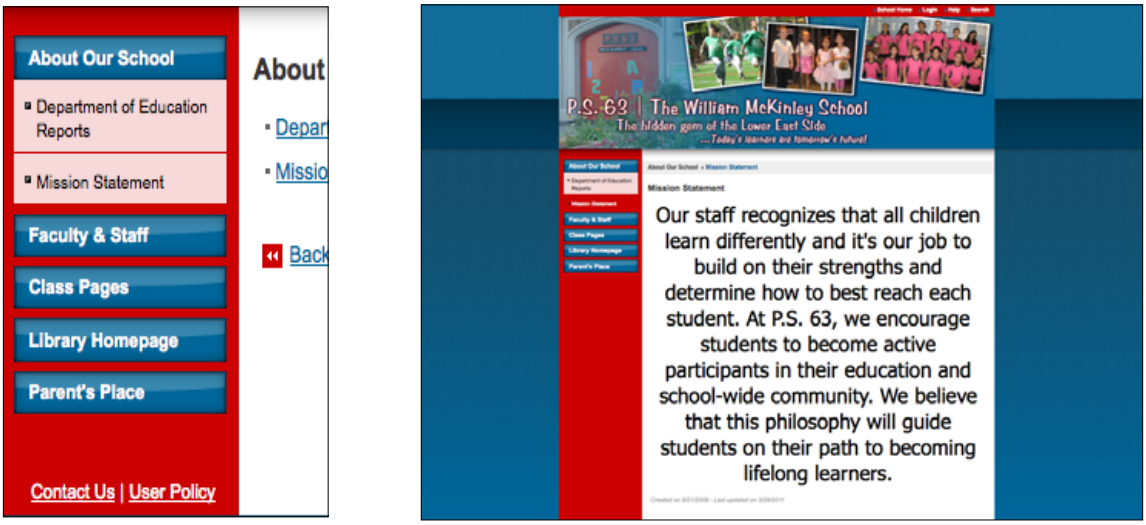

Figure 10. Screen Shots from the P.S. 63 Web Site ("P.S. 63," 2011)

The structural way the information is designed, while highly ineffective, comes second to the elemental problems. The main elemental problems are: color palette, typography, and logo design. Blue and red are the dominant colors, however it is ineffective because there are many different shades of blue located in various rectangular quadrants that prevent visual cohesion. The typeface is haphazard and the scale of the body text, as seen in the right screen shot of Figure 10, is much too large for the page; it dwarfs everything around it. It is also set in Arial, which is a poor-quality typeface that was constructed as a copy of the well-respected and solidly constructed Helvetica (see Figure 11 for further clarification). Additionally, the P.S. 63 web site header displays the logo (good), mission tagline (good), but unfortunately the design of the logo is subpar. The typeface is cutesy and is saddled with an ornamental drop shadow that is reminiscent of an old PowerPoint slide. There is huge potential for P.S. 63 because of their strong mission statement and unique offerings as a school.

Yet this potential is obscured by poor design and inconsistent communication.

Figure 11. Arial and Helvetica Analogy

Effective Information Design

In K-16 education, there are select instances of effective information design most noticeably at the higher education level, however examples are also found at the elementary level. This section will first explore what effective information design looks like. It will then examine effective information design in Reggio Emilia style education and a school located in downtown New York City that operates within the Reggio philosophy. Additionally, this section will look at a new public charter school that will eventually house grades 6-12. Higher education will also be included. The main focus of this section will be on effective information design within science as a whole. Lastly, the subject of effective information design in environmental venues will be visited.

The Experts

Despite the newness of the field of information design, there are a few formidable figures that were visionaries in the 20th century before the field even existed. In the present day, there are several well-known leaders in the field who are working to carve out a niche for information design. The degree of success in visualizations is debatable, however there are many consistencies throughout the industry. In addition to leading figures, there is much to be learned from a corporation that successfully employs information design in its projects and has even assembled an entire data visualization team.

Leading Figures

Richard Saul Wurman (b. 1935) is best known as a founder and chair of the Technology Entertainment Design (TED) conferences from 1984-2002. With Master of Architecture and Bachelor of Architecture degrees from the University of Pennsylvania, he has been awarded several grants from the National Endowment for the Arts, a Guggenheim Fellowship, two Graham

Fellowships, two Chandler Fellowships, and was inducted into the Art Directors Club Hall of Fame in 2003 (Wurman, n.d.). Wurman coined the term "information architecture" nearly 30 years ago. In an interview with Dirk Knemeyer (2004), Wurman explained that his inner drive serves "the God of Understanding." He believes that the next wave of convergence is that of medicine and the components of TED; Wurman created the TEDMED conferences in support of this belief. Wurman has long based his success on the idea of questioning and finding answers to difficult questions using information design as a means to clarity. He points to a historical example: "It was something like 26 years after the first Gutenberg Bible that somebody invented pagination. Page numbers allow you access; it was one of the first steps in trying to understand things and find things. History teaches us that people will struggle with the obvious. Try to discover the obvious ways that make things clearer. Try to search for clarity" (Knemeyer, 2004). The broadness of Wurman's position on effective information serves the greater end of simply achieving clarity. The exact way of doing so remains clouded, however there are other leading figures that offer more concrete guidance.

Edward Tufte, who has legendary status like that of Richard Saul Wurman, asserts that clarity is the goal of effective information design. However, unlike Wurman, Tufte is extremely thorough and subsequently lays out the specific ways to achieve clarity through his books, web site, and continuing education seminars. In his book Envisioning Information, Tufte (1990) lays out the premise that "to envision information—and what bright and splendid visions can results—is to work at the intersection of image, word, number, art…the standards of quality are those derived from visual principles that tell us how to put the right mark in the right place" (p. 9). Designing information is not a mysterious art, but rather a scientific process that is guided by concrete fundamentals.

There are some basic rules Tufte outlines for effective information design that include the following insights gleamed from his New York seminar, Presenting Data and Information (November 4, 2010):

1. Software. Statistical graphs are really, really bad. Tufte advises to use Microsoft PowerPoint as a projector only. Tufte explains, "Word and Excel won't do it; you'll need a real layout program. You'll know it's one because it will cost $500." Adobe InDesign and Illustrator are the quintessential design programs. For a serious scientific statistic program Tufte recommends Origin.
2. Typography. Gill Sans is preferential for chart typefaces, but Tufte points to Trebuchet as an option for Microsoft/Windows users without Gill Sans in their font reserve.

Additionally, capitalization matters and subtlety is important. Tufte reprimands the use of all-caps sans serif in a box because the letters are difficult to differentiate when the height is all the same.

3. Color. Keep it simple. To reduce optical clutter, stay away from using black and white; instead use gray and white because it has less contrast. Tufte (1990) recommends using colors found in nature, especially those with a lighter side like blues, yellows, or grays; nature's colors are familiar and coherent, providing harmony to the human eye (p. 90).
4. Ordering. "Rarely, if ever, should tables be by alphabetical order." Sports-related data, for example, should be ordered by performance, not alphabet.
5. Paper. A serious presentation demands serious paper. Do not use glossy paper for a serious report just because it is expensive and alluring; it will come off as trying too hard to appeal by aesthetic alone.
6. Visual accessories. Do not use them. One must find a way to integrate context and visuals by thinking entirely about the content and getting away from "cute designs and bullet points."
7. Use a supergraphic. It is an intense, relevant data visualization that is high-resolution, gets your audience thinking, and takes a bit of time to digest.
8. Lines. Effective "lines have a high-resolution lightness and clarity, similar to typography. Finely textured lines avoid the optical clutter and moiré vibration of heavy lines (Tufte, 2006, p. 71).

Sparklines are good. Tufte spoke of how one is designed by having audience follow along in his *Beautiful Evidence* book (p. 47). Sparklines are small, high-read graphics usually embedded in a full context of works, numbers, or images. They "hold huge amounts of data and even the higher ups can understand them," said Tufte (November 4, 2010). While Tufte dissects visuals all throughout the seminar, he focuses intently on design decisions in a glucose sparkline (Figure 1) that he created.

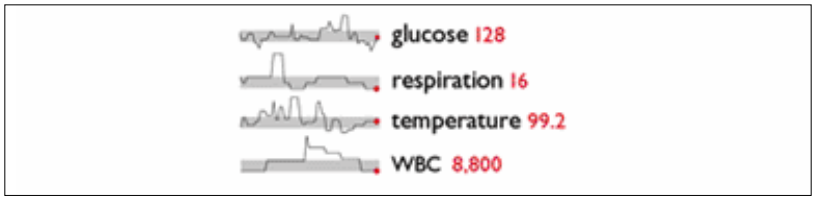

Figure 1. Edward Tufte's Sparklines (2006a, p. 6)

It is so simple, yet so rich in information.Visible are the current glucose reading (red), the number relative to the history of readings (red dot), and the median range of readings (gray bar) relative to the current reading. Because the sparkline is so compact other relevant readings, such as temperature, are able to be included for a very full picture in just 2 square inches of space.

Similarly, whisker mark visualizations (Figure 3) are highly effective at communicating a lot with a little. In his seminar Tufte describes this type of visual as straightforward, easy to see, luscious, complex, and all about content. Tufte (2001) argues that "the best designs are intriguing and curiosity-provoking, drawing the viewer into the wonder of the data" (p. 121). The same conviction was echoed in the AIGA/Pentagram seminar at Parsons (January 12, 2011).

The Parsons seminar, Data Visualization: Methods & Madness, was one of the first of its kind which made it feel like a landmark event in the up and coming field of information design. One of the speakers, Lisa Strausfeld, who is a partner at the highly successful and lauded design firm Pentagram, simply and eloquently described effective information design: The best visualization happens by losing oneself in a story. Fellow panelist Laura Kurgan describes such a case called The Million Dollar Blocks Project (2005) that was created through Columbia University's Spatial Information Design Lab.

The United States currently has more than 2 million people locked up in jails and prisons. A disproportionate number of them come from very few neighborhoods in the country's biggest cities and in many places the concentration is so dense that states are spending in excess of a million dollars a year to incarcerate the residents of single city blocks. When these people are released and reenter their communities, roughly forty percent do not stay more than three years before they are reincarcerated.

The maps suggest that the criminal justice system has become the predominant government institution in these communities and that public investment in this system has resulted in significant costs to other elements of our civic infrastructure — education, housing, health and family. Prisons and jails form the distant exostructure of many American cities today, according to Kurgan. There are stunning repercussions for social policy and civic infrastructure. This work employs design thinking and tells a story by linking poverty to incarceration to justice and has repercussions for social policy and urban planning.

Data was re-imagined into an interactive visualization of mapped out addresses of formerly incarcerated individuals; one color in specific hues is used to highlight the cost of their incarceration

(Figure 12).

Figure 12. Million Dollar Blocks Project Screen Shots (Kurgan, 2005)

The color palette is black, deep red, and gray and is striking in the way the black allows the red plotted squares to stand out so vividly. This is an effective example of information design because it is restricted to the most essential data needed to tell the story. The visual elements (geography, color and cost) are kept to a minimum and the gray area around the focused area neutralizes the inactive elements in the visualization without removing context. A notable theme that emerged from the AIGA event is that data visualizations allow us to consume a rich and vast amount of data quite easily so that we learn a lot by a designer's close examination. The Million Dollar Blocks project exemplifies this theme, especially since it is still an active project six years after its inception.

Consuming a rich amount of data in a condensed visualization is the goal of information design guru David McCandless. He creates effective data visualizations that are pure examples of creative problem solving by a design thinker who understands the field of information design. Like Richard Saul Wurman, Candless' driving force is his desire to appease his curiosity by finding understanding. As a reaction to information overload, McCandless creates useful and meaningful visualizations that tell a story and make specific subjects—such as the carbon dioxide cycle or the evolution of computers—easier to consume and see as a whole. Seeing and absorbing through vision is in accord with the visual nature of modern day culture in which digital images pervade daily life.

The way in which McCandless organizes the information in his book is nothing short of innovative. Typically, a table of contents (TOC) lists the information of a book in pagination order and is grouped in chapters, units, etc. Sometimes, however, that is not the most efficient way of structuring an outline of the contents of a book. McCandless deliberately chose to order the

visualizations in his work in such a way that complements the miscellaneous nature of the book. His TOC (Figure 13) groups the visualizations according to subject matter (e.g., music, media, science, web), which is helpful for navigation. We are so accustomed to listing things in numerical order that authors rarely adopt the qualitative method of organization. McCandless maintains consistency in the TOC by keeping the section heading type white knocked out in each of the colored circles. Moreover, the color palette of the circles mimics the colors of his book cover and many of his visualizations. It is neither strongly saturated nor dull and faded. There is a degree of neutrality that carefully balances the content so that no color really overpowers another. Similarly the index is of great functionality in a visually appealing way. It presents thumbnail graphics from each graph so that users can quickly and easily locate a specific visualization.

Figure 13. Table of Contents from *The Visual Miscellaneum* (McCandless, 2009)

Professor Brown agrees that the index is innovative and that if he wrote a textbook, it would feature something similar (interview, January 11, 2011). Science education could benefit from the design thinking at work in effective information design.

The immortality visualization matrix (Figure 14) is incredibly complex in its richness of detail that is condensed into a highly legible form. While the data used is scoured from open sources on the

internet and thus may not be completely reliable, it is good enough for this level of understanding. Undoubtedly it came out of the age-old question of how to live longer. McCandless put together biographical information taken from famous people who have lived long lives in an attempt to find repetition, which is indication by lightness or darkness of color. It also isolates the y-axis variables by most saturated so that the mode element is called out as a tag on the far right (e.g., lived in a city).

Figure 14. Immortality Matrix from *The Visual Miscellaneum* (McCandless, 2009)

The Corporation as Expert

One of the world's largest leading companies in the field of information design is General Electric (GE). General Electric has wisely assembled a "posse" of information designers and is thus serving as an example for their corporate peers, according to expert Lisa Strausfeld (2011 AIGA/ Pentagram seminar). According to GE, visualization is a powerful way to simplify complexity and they are committed to advancing the conversation about issues that shape our lives ("GE data visualization," 2011).

The home appliance energy use interactive visualization that is found online lets users understand how much energy (in dollars, watts, gallons of gas, kilowatt hours) is used for a host of specific appliances (see screen shots in Figure 15). This design helps consumers understand wattage and energy use through a simple, intuitive interface. Such an interface exemplifies a basic tenant of design thinking which, according to Tim Brown, is to provide a more human-centric experience. The design consists of neutral gray renderings of appliances; there is a task bar at the top with a clean

interface for selecting different view modes. Color is kept at a minimum except at the most important areas (the actual usage data in small, blue windows and the total energy usage in red at the lower right corner). The grid system is also visually satisfying.

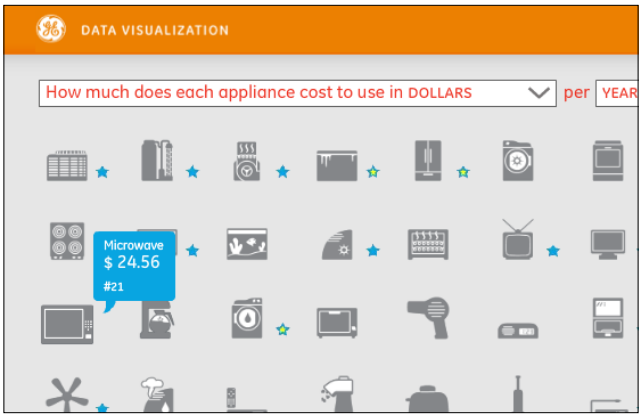

Figure 15. General Electric (GE) Energy Use Visualization Screen Shots (*GE Data Visualization*, 2011)

This is a big picture instance of the broader utility of information design for the benefit of the general public. Like the TurboTax visualization mentioned in the Demand section, this project by GE demonstrates the financial benefit of including information design in business efforts and that it can be of good design.

Effective Data Visualizations in Science

Science instruction needs art. Information design is an essential and necessary part of science education because most science concepts cannot be explained without a visual representation. The quality of the visualizations may not be consistent, but they are nonetheless vital to understanding many ideas and processes. The science field is full of effective visualizations. They do not exist in troves, but they do exist. One relatively consistent source of effective visualizations is the journal *Nature*, which is recommended by Edward Tufte. *Nature* is one of the leading science publications and is based in the United Kingdom. *Science* magazine is similar to *Nature*, however is based in the United States. Scientific research studies in higher education laboratories also require visualizations, however it is up to the research team on whether or not to enlist designers in the laboratory process.

Success in a Higher Education Science Research Project

One such project was the E. chromi collaboration between designers and scientists in the new field of synthetic biology. In 2009, Cambridge University undergraduate students in the

iGEM team genetically engineered bacteria to secrete colored pigments. They designed standardized sequences of DNA, known as BioBricks, and inserted them into E. coli bacteria. Each BioBrick enabled the bacteria to produce a color: red, yellow, green, blue, brown or violet. By combining these with other BioBricks, bacteria could be programmed to do useful things, such as indicate whether drinking water is safe by turning red if they detect a toxin. The iGEM team worked side by side with students from the Royal College of Art in Design. E. chromi won the Grand Prize at the 2009 International Genetically Engineered Machine Competition (iGEM). It was also nominated for an award in the prestigious British Insurance Designs of the Year 2011 and was on exhibit at the London Design Museum.

Figure 16. E. chromi Project Video Screen Shots (Ginsberg, A.D. & King, J., 2009)

The visual identity of the project is very strong. The color palette is consistent throughout all related material; it is understated and complements the project rather than distracts viewers. The logo is simple, scalable, memorable and versatile; it even incorporates the curvature of an actual E. coli bacterium through the curve of the "E." The three circles bring color and life to the design and also invoke a microscope lens or specimen dish. The typeface used throughout all collateral is consistent and, through its humanist design, reflects the friendly, approachable and contemporary nature of the project. Supporting elements like the screen shot from the project's video (lower right) are clean and simple, as is the steel suitcase that contains the prototypes. It is notable that the clean, pared down aesthetic does not strip down the information as much as some scientists might argue. It is an exemplary example of the creativity produced through information design when scientists and designers work together.

Successful Design in an Academic Publication

Science magazine's annual Visualization Challenge offers the opportunity for scientists to submit designs that effectively convey the information behind their projects. There are four categories: Illustration, Informational Graphics, Photography and Non-Interactive Media. The 2010 winners were chosen by a panel of five experts, however not one of them is associated with a design firm or anything arts related; the closest relation is a television producer of a science-related videos and series (Nesbit, N. & Norman, C., 2011). Regardless, the winners of the 2010 Challenge in the Illustration and Informational Graphics categories created effective designs that communicate information visually.

The finalist in Illustration is a 3-D rendering of an HIV particle (Figure 17). It was created by a team at the Visual Science Company in Moscow and does an excellent job of communicating how the HIV virus hijacks host cells through the visual's use of color, texture and focal point.

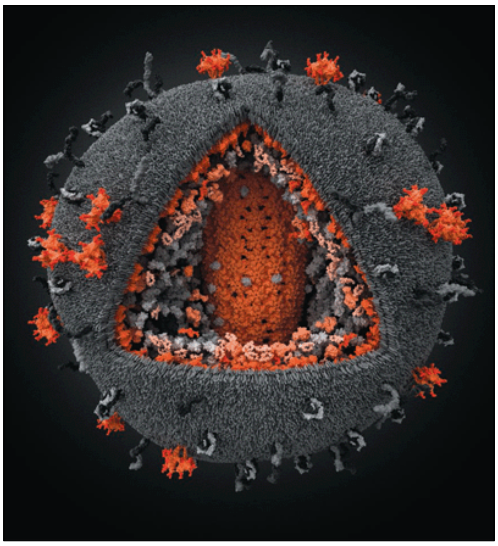

Figure 17. HIV Illustration from *Science* Visualization Challenge (Nesbit, N & Norman, C., 2011)

A triumph in reduction, the illustration shows the host cell in two different shades of gray and the HIV virus in two different shades of orange. The color orange psychologically conveys action and energy, which fits with this type of viral activity. Gray provides neutrality so as to allow the orange to stand out since it is the subject of the illustration. Since the inner host cell is gray, there is no confusion that shadow could create by being the same color as dark gray. Light gray keeps the inner cell distinguishable from the exterior cell, which aids in providing a good view of the host cell membrane fusing with the virus shell. Judge panel member Tom Wagner praises the visualization

by recognizing its intense focal point, albeit without directly stating the artistic element: "You have this gaping mouth that almost looks like it's ready to eat you the way AIDS is eating away at society" (Nesbit & Norman, 2011, p. 847). While there is no alpha or numerical data visible in the visualization, it nonetheless communicates a lot information with elegance and great economy of design.

Effective Information Design within Higher Education Science Classes

There are many types of effective visualizations found within science classes in higher education. They can be organized by use into two main categories: use by the teacher and use by the students. It can be difficult for a teacher to find good visualizations; many are needed and the original sources like journals and textbook may not employ professional designers to handle their visualizations. However, at Art Education University there are very good data visualizations both in the teacher's sourced materials and his own creations.

Teacher-led Visualizations

What does it mean to have an effective visualization as a teaching tool? For the higher education teacher it is important to be able to communicate concepts with clarity and reliability. The data should not be faulty and, depending on the topic, there must be complexity that renders it appropriate for college students and not a general audience or lower grade levels. Professor Brown does a sweeping search through books, climate change reports, films, and articles from *Nature*, *Science*, *Wired*, *The Economist*, *National Geographic*, *Scientific American* and others (interview, January 11, 2011). As a result, many of the visuals he uses in classroom discussion exhibit good design. Sometimes he adds design elements on top of them in order to create consistency throughout his presentations and relevancy to his students. For example, using the layout program Keynote, Professor Brown will overlay type over the type on the visualization; this typeface will then be used consistently in his slides. Not only does this create unity, but it also makes the text more legible from a distance for students to take in the information easily.

The use of Apple Keynote as presentation software, as opposed to Microsoft PowerPoint, heightens the design factor. Equipped with solid layouts and intuitive interactivity, Professor Brown is able to design information with ease and clarity. Information is presented without much "optical clutter" and with respect to balance, proportion, grid systems and consistency. The typeface is a

relatively neutral sans serif—akin to Futura or Helvetica—which allows the content of the slide to speak. Moreover, only the most vital parts of the topic are given in the presentation so that screen does not overshadow speech or become an educational crutch.

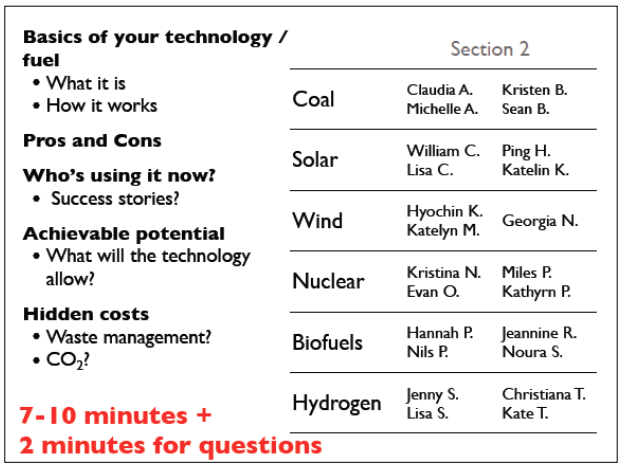

Figure 18. Slide from Professor Brown's Energy Presentation (class observations, February 8, 2011)

A table (Figure 18) appears in a slide for a class on energy that lists student names in groups based on six energy types. The design is striped down to basic line and text without the clutter of border lines, bullet points or numbering. The strict vertical alignment for each of the three columns negates the need for vertical dividing lines; only horizontal lines are needed. The type is set in black except for the heading of the table, which is gray, and an important note about work time on the bottom of the slide that is red. It is difficult to imagine a better way of constructing a table for this purpose. The only minor change that could be made would be for the information that is listed outside of the table. "Basics of your technology/fuel" falls into two lines with an orphan (one word on a lower line). This could be corrected simply by moving "technology/" onto the second line with "fuel." The same is true for the "technology allow" under "Achievable potential." However, this typographic correction is pedantic.

Student-led Visualizations

Student creation of data visualizations is not prevalent in the science courses that were studied, however it is integrated in varying degrees throughout classes. It was found that assignments that deliberately called for visualizations were given during class time. The artistic background of being enrolled in Art Education University appears to have an influence in the quality of the students'

works. Some students were more motivated than others. One in-class activity took the majority of class time and relied almost exclusively on drawing and illustrating.

Within an undergraduate ecology class, students were split into groups for an in-class activity about biomes. The class assembled into eight groups and each one was given a worksheet and assigned one of these biomes: tropical rainforest, tundra, taiga, prairie/grassland, chaparral, temperate deciduous forest, desert and temperate rainforest. After answering the worksheet questions each group passed a large drawing board with paper and markers, along with the worksheet, to the group on their right. At each turn, groups were told to draw specific aspects of the biome: biome setting, biome animals, food web relationships and threats to the biome. The activity concluded with a "crit" of each biome wherein the illustrations were explained by the initial group that completed the worksheet.

Despite it being an art school students were reluctant to draw and even called themselves "bad drawers" potentially as a protective mechanism. The engagement level of the students was very high and everyone participated to some degree. Since the boards of each biome were exchanged across all groups, everyone had an opportunity to add to one another's boards. As a result, there came to be friendly competition, but it was not centered on creating the most accurate biome in terms of drawing ability and biome accuracy. Rather, the competition was in the hilarity and humor of creativity within the biomes. Political jokes permeated nearly all of the biome illustrations. And there was even an appearance by John Lennon. As a result, it was difficult to find the visualization techniques created by the students. It was found that the drawn details gave some sense of information design understanding. For example, all of the groups used arrows to show the food web relationships. Some of the arrow points were more fully formed and larger than others; some were intended to stand out among all of the other visual elements on the entire drawing by use of color. Little time was dedicated to figuring out a structure because so much energy went into the narrative element of the activity; that is, what animals or figures to draw and how to create a story within the biome.

Nevertheless, students were forced to deal with finding ways to represent qualitative information. Design decisions were being made throughout (e.g., how to orient the page, where to write the name of the biome, marker color) the activity that fostered creative problem solving. There was no doubt that the students really enjoyed the class and were fully immersed in active learning so that the final product was not necessarily reflective of the learned content.

The prairie and grassland (Figure 19) biome was fully formed with all of the required

elements integrated into the drawing. The location of the biome was conveyed by a long horizontal arrow at the bottom with "forest" labeled at one end and "desert" at the other, which visually conveyed the general location of the biome. The animal food web was constructed with precision so as to portray the relationships within one specific section of the composition. The realistic renderings of the bird, wolf, mouse and snake stand out. Because the biomes were passed from group to group, the result was a smorgasbord of detail that reflected different artistic expressions. There was also vested interest in each of the biomes since each person had a stake in each of the drawings; this also had the positive effect of eliminating the "mine vs yours" competitive classroom environment.

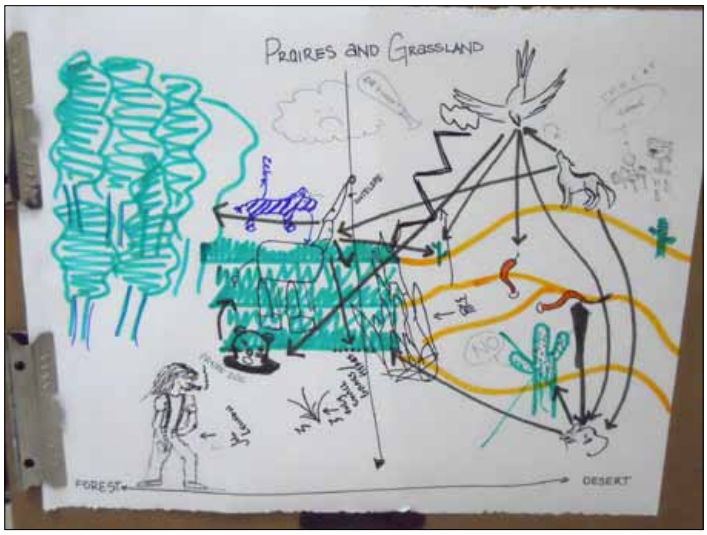

Figure 19. Prairie and Grassland Biome Drawing (class observations, February 16, 2011)

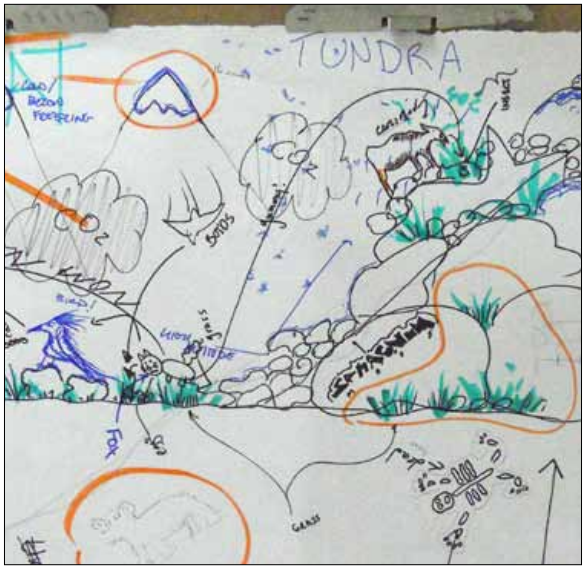

Figure 20. Tundra Biome Drawing (class observations, February 16, 2011)

The tundra biome (Figure 20) began with a landscape drawing in profile that invited the drawings of animals and plants which were added later. The threats were illustrated by the use of a bright orange marker as well as a visual of CO_2 that was presented as a cloud. The biome activity demonstrated the utility of collaborative learning. Everyone entered the class with varying abilities and because the biomes were constructed through the efforts of each student, the assignment reflected a heterogeneous understanding of the biome. Some students filled in the missing elements as they worked within parameters drawn out by the previous group. Biomes are very visual conceptually, which makes a landscape illustration more conducive to learning than would a graph or chart-style construct. Nevertheless, the biome project was a demonstration of student ability, which conveyed that the class had the potential to render more concise visualizations in future information design assignments.

Effective Information Design within Secondary School Science Classes

The existence of information design as an independent entity within secondary schools is virtually non-existent. It is limited to textbooks and examples culled by teachers to assist student learning. There are pockets of educational initiatives that attempt to empower science learning. One such initiative is that of *The New York Times*' Learning Network section that develops lesson plans which are connected to real work issues, some of them scientific. As one of the largest media outlets in the world, the Times has great influence on communities. Accordingly, when they decided to declare an "Infographics Week" in August 2010 and develop an entire section on infographics in education, it spoke to the interest in, and benefit of, learning about information design on all education levels and not just higher education.

The content of *The New York Times*' online infographics section provides an overview of what information design is, where it is being used, and ideas on how to bring it into classroom learning. In the Science and Health sub-section, Holly Epstein Ojalvo (2010) compiled examples of Times information design under varying categories such as Viruses, Nutrition, Space Exploration, Climate Change and Energy. Additionally, there is a brief case study that focuses on a three-week long student project conducted by social studies teacher Diana Laufenberg to create infographics that effectively told the stories of the top ten worst man-made environmental disasters in American history (Schulten, 2010). This inquiry-driven learning experiment stands as an example of effective information design being applied in a classroom setting for furthering secondary school education;

note that the subject is social studies, not art. At this point in time, it is simply too early to find examples of effective information design created by secondary school students.

Pictures vs. Visualizations

It can be easy to confuse pictures and visualizations. There is overlap and not a clear line between the two although it is helpful to examine the divide by realizing the utility and learning intake provided by the visual. If the information can be communicated without words—like the HIV particle featured in *Science*—then it can be categorized as a visualization, but not a data visualization. Visualizations can be effective in communicating information even when there are no words or numbers. Pictures do not contain a sophisticated level of information, but they can still be useful in science classes. Since information design is not fully formed or well-understood, pictures and visualizations still have a place for study in the field. This section examines effective examples of each within the areas of higher education science classes, the science field, and other scientific avenues.

Higher Education Science Class

One example of a discrepant visual is the overall imagery used in teacher presentations in science classes. While a good chart or other quantitative structure may comes as useful for learning, an image can also be useful during class lecture or discussion if it does the job of better explaining information. Sometimes, however, an image is used in a presentation as a "gaze fixer" so as to draw pupils into the content in an almost hypnotic way while information is being transmitted auditorially through what the teacher is saying. The image is a photographic illustration of New York City as imagined 500 years from now if humans had disappeared. It was projected during Professor Brown's class on Biomes, Forest Succession, and Disturbance for five minutes while there was teacher-lead discussion. Lingering on one image was an effective teaching and learning tool because it represented the content of the lecture and helped maintain student focus. It also helped the dialogue by providing visual context. There were pictures on other slides in the presentation that acted as a backdrop for what Professor Brown was talking about. They consisted of a sole image or an image plus key terms. This usage makes the case for two important utilizations of design in science classes: background/ backdrop (for a somewhat theatrical function) and visualization to illustrate something specific.

Visualizations within the Broader Science Field

There are impressive visualizations within the professional scientific community that are not necessarily data visualizations per se, but communicate information in an effective way. The Harvard BioVisions lab is behind some of the more impressive animated visualizations. One of their molecular animations, that *The New York Times* describes as when "cinema and biology meet," features a lurid depiction of how mitochondria power the cell (Olsen, 2010). The animation brings highly digestible visual representations to life for audiences who have only read about processes. Dr. Lue, a professor and the Director of Life Sciences at Harvard, is one of the pioneers of molecular animation, a rapidly growing field that seeks to bring the power of cinema to biology (Olsen, 2010). The field has spawned a new breed of scientist-animators who not only understand molecular processes but also have mastered the computer-based tools of the film industry. Janet Iwasa, a cell biologist who now works as a molecular animator at Harvard Medical School, started in the field by attending a three month animation boot camp at the Gnomon School of Visual Effects in Hollywood thanks to a grant from the National Science Foundation in 2006 (Olsen, 2010). While this type of graphical representation is more akin to "picture" than "visualization," it pushes the boundaries of what is considered to be in realm of information design. In a broader perspective, the work of Harvard's BioVisions lab brings attention to the expansive possibilities that come from fusing art education with science education.

Other Scientific Avenues

Not limited to the hard or life sciences, there are other instances of science meeting art through visualizations that seem to fall into a miscellaneous semi-qualitative category. *Mrs. Ma's Chinese Cookbook* by Nancy Chi Ma (1972) features a sheet of vellum, over food ingredient images, that is printed with the food names. The cookbook offers the reader the ability to consume the information with or without label mapping. This type of flexibility is appealing to users because it invokes the feeling of personalization that gives a person a deeper sense of ownership.

Another example in the food sciences domain is the representation of food ingredients for recipes (Figure 21) in the Swedish cookbook, *Homemade is Best* ("IKEA – Homemade," 2010) It won the Graphics Award at the London Design Museum's Brit Insurance Designs of the Year 2011. Swedish interactive graphic agency Forsman & Bodenfor exploited composition to create a minimalist, yet colorfully dynamic, and proportionally sound depiction of ingredients like butter sticks, eggs, sugar piles and cream spills.The designers solved the problem of homogenous cookbook photography by bringing innovation and divergent thinking to the design of information. Again, this is not data per se—although the quantities are represented through the size and amount of each

ingredient—but it straddles the fence between pictures and visualizations.

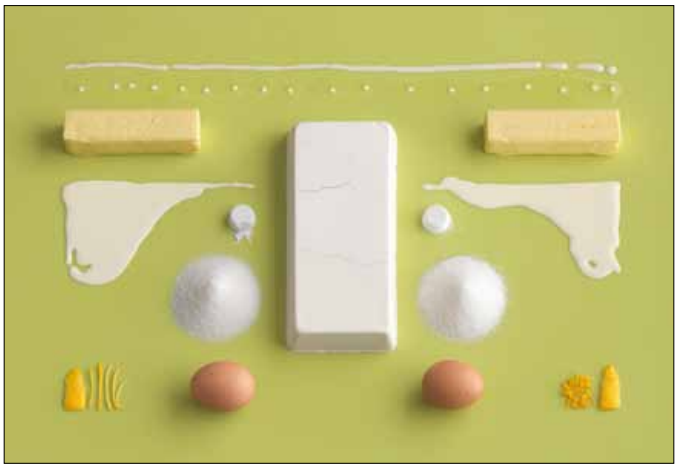

Figure 21. Image from *Homemade is Best* Cookbook ("IKEA – Homemade," 2011)

Information Design's Environmental Presence

Information design is not limited to the printed page or digital screen. It also exists within the school interiors. While not specifically attuned to science, the examples here point to the use of information design for visualizing information that is important enough in the classroom to be put in highly visible locations for extended periods of time. The Reggio Emilia philosophy of education prioritizes children's encounters with their environments which means that design has a big influence in the classroom. Environment is the third teacher.

Environmental design focuses on how children perceive and use space to create meaning. Typically utilized in early childhood education, environmental design in Reggio Emilia-inspired classrooms is effective in building positive relationships with space for students and their families. Spatial design also supports classroom management for teachers and it supports students in constructing knowledge through experience. Materials are central to the Reggio approach. According to the Reggio philosophy, "By storing colorful objects in transparent containers (markers, buttons, fabrics, wrapping paper), which children can help sort by color or texture, children's curiosity and imagination are piqued…the materials are carefully selected and arranged to invite exploration" (Strong-Wilson & Ellis, 2007, p. 42). Since there is then a large amount of materials to organize, their arrangement falls into the realm of design. Materials like stones, netting and paint are the types of information that young children use and access in school settings. Therefore, arrangement becomes

an important aspect of this early childhood type of information visualization.

In addition to arrangement, wall display is another component of information design and includes explanatory text and the children's own words, which helps a viewer understand children's thinking and their processes rather than just end products. Documentation, another cornerstone of Reggio Emilia education, expands upon display that welcomes "inquiry about the children's thinking and invites predictions about effective teaching" so that it is ongoing and a part of planning and assessment (Gandini, 1998, p. 245-6). Documentation encourages children to revisit an experience and to share a memory together, and it can provide opportunities for further exploration or for fostering new directions (Gandini, 1998). As such, making sure that the explanatory text is set in a legible, high-quality typeface is an important facet of information design so that the young children and their families are able to revisit those experiences and preserve mental access.

The Blue School

The Blue School is a Reggio Emilia-inspired school for children in grades K-2 that is located in downtown New York City. Environmental design is an articulation of the third teacher. In The Blue School information is designed from hallway to wall to floor (open house, November 15, 2010). There is a consistent use of a single light, contemporary typeface—Century Gothic—throughout the hallways and in the classrooms. It is evident that The Blue School values the presentation of information.

Figure 22. Photograph of a Blue School Classroom (open house, November 15, 2010)

Student work is typically displayed on brown cardboard or brown recycled paper; this is consistent

all throughout the entire school. Even nametags are specially placed to balance out a display. These design decisions demonstrate that The Blue School considers composition important for effective information design. Elements of interior design like furniture and fixtures are also components of the school environment that support information design by acting as mediums of containment. In The Blue School student work is frequently hung on the wall in grid systems that reflect order. Additionally, the main hallway on the ground level has large, white globe lights that emit a soft luminescence that feels inviting and enveloping. By using a few large lights in lieu of several small lights or fluorescent tube lights, there is less optical clutter on the ceiling, which contributes to the overall openness of the space and Reggio Emilia educational philosophy.

There is strong clarity in the space at The Blue School. Good environmental design relies on maintaining a position between sparse and cluttered. Specific parts of the space—such as a numbered calendar or corner of hanging mobiles—should be given room to breathe and stand on their own without interference of other objects or background distraction (color, posters, student work, etc.). Accordingly, neutral tones like warm white, beige, light gray, brown, etc. allow the work to stand on its own. That is why the use of brown paper is so effective in promoting the design credo of Reggio Emilia-inspired education.

Visual Identity

An oft forgotten element of information design within schools is visual identity and branding. With the increased competition for funding and the attraction of high-achieving students, the criteria on which K-12 schools are judged are changing. Of course the judging of a school's reputation and academic strengths continues to be of utmost importance and continues to evolve. However, the foundation of a school's reputation is its visual identity which needs to remain the same to withstand the tests of time within public awareness. A strong identity relies on purposeful presentation that is communicated to students, faculty, prospective students and families, and the general public. The primary components of a school's visual identity include logo, color palette, tagline, interior/exterior design, online presence, and printed materials that reflect any of the aforementioned features. Information design is a factor in the layout and construction of these components.

Effective visual identity is supported by distinctiveness. This is also known as the unique position (in advertising this is called the Unique Selling Proposition, or, the USP) of the organization

in the minds of its strategic constituents. In a study conducted on the visual identity of Syracuse University, researchers Alessandri, Kinsey and Lang (2006) found that distinctiveness can yield 'top-of-mind' awareness of an organization's products and/or services in stakeholders' minds, which in turn often leads to the favorable reputation of an organization. Additionally, the researchers discovered that there are certain components that contribute to visual identity more so than others in the minds of students. A stronger visual identity (i.e., more distinctive perceptions of university visual attributes) resulted in a more favorable reputation for the university and salient components of the visual identity (i.e., the distinctiveness of certain visual attributes in the minds of the research participants) were strongly associated with similar aspects of the university's reputation—a priming effect of visual identity in the participants' cognitive representations, or reputation. (Alessandri et al., 2006). While it is an examination of just higher education, this study's implications can be applied to all education levels.

One of the strongest visual identities of a school in New York City is that of the 6-12 grade District 2 public charter school, Quest to Learn (Q2L). Typically, effective school branding begets effective information design. Q2L successfully delivers effective information design in their public communication through their solid visual identity. The visual identity is sound for many reasons. Namely, it is supported by a clear, articulate mission statement that is not as broad as those of other schools.

> Design and innovation are at the heart of Quest to Learn (Q2L), a school committed to helping every student to achieve excellence in the skills and literacies necessary for top college and career readiness. We believe that students today can and do learn in different ways, often through interaction with digital media and games. Q2L builds on this belief to create a nurturing and vibrant 6th-12th grade school environment that supports all students in the pursuit of academic excellence, social responsibility, respect for others, and a passion for lifelong learning. ("Quest to Learn: Mission," 2011)

Q2L has also stated a reason and purpose for their school that gives weight to their mission statement:

> Designed to support the digital lives of young people and their capacity for learning, Quest to Learn is a school committed to graduating strong, engaged, literate citizens of a globally networked world. Through an innovative pedagogy that immerses students in differentiated, challenge-based contexts, the school acknowledges design, collaboration, and systems thinking as key literacies of the 21st century. ("Quest to Learn: Reason," 2011)

These excerpts represent only a fraction of the information available on the Q2L web site. As a school centered on systems communication, exploration, and digitalization, Q2L preserves transparency and

organization in their online presence. By opening themselves up to the world Q2L must maintain a cohesive visual identity so as to support and strengthen their mission and purpose.

The consistency found in Q2L's visual identity extends to logo, color palette (Figure 23), typography, online presence and collateral. Usually, the combination of blue and orange is not good because each of the two colors is vibrant and strong in its own right so that by pairing them together, the whole is explosively overpowered by itself. Just one of those colors in a visual identity is enough to make a profound stand to carve out a solid niche for a brand. Some of the most recognizable and successful brands consist of a one-color branding. For example, Nickelodeon is orange, IBM is blue, Coca Cola is red, and Starbucks is green. Q2L's visual identity utilizes both blue and orange, however the blue is used more heavily than the orange.

Figure 23. Quest to Learn Visual Identity Color Palette ("Quest to Learn: Mission," 2010)

The result of this proportioning is that orange that acts as a spot of energy that helps the brand wiz by in the same fashion as the speed of electronic processing; this reinforces the Q2L brand by tying in with the mission statement. The enduring translation of the color blue is tranquil and cold; the addition or orange warms the brand up without overheating it. The color of Q2L typography is mostly a medium gray, which provides enough neutrality to preserve the foreground held by blue and orange. As Edward Tufte advises, black is too harsh for type, which should be supportive without taking over as "optical clutter."

The logo is used consistently throughout branded collateral. As with any well-thought out logo, Q2L devised different versions of their logo that work in a variety of printed contexts: black and white, small scale, online color, printed color, etc. For example, the lesson plans are in black and white (color is not needed for this type of information) so the black Q2L logo is used. Some of their electronic files in the media kit and parent kit feature a consistent title page with a large "Q" that contains the Q2L logo and tagline "School for digital kids." Blue is not used here, however the same gray of the type is paired with orange. Total uniformity would be too strict for a school that is founded in openness. The typeface used by Q2L is a contemporary sans serif typeface that has,

because of the rounded ends of the letters, a light touch of an LCD-style electronic display. The designers did not over-exaggerate the digital nature of the school by making the entire logo in the short, broken lines; this would be too kitschy and novel. Rather, this stylization is evident in just the "to" part of the name. After all, the school does have other learning subjects and styles apart from the digital; wellness and socialization are core domains of Q2L learning as well.

The design of the Q2L web site is rich in information, yet the design is simple. The menu system is layered by headings and subheadings without any cutesy animation or effects. The type is consistently gray and uses blue for highlighted and active link text. The blue found in the text corresponds to the light blue of the web site background, which remains consist throughout all of the pages. Additionally, three frequently used links are called out on the bottom left of the menu and serve to anchor the page composition by visually corresponding to the orange in the logo on the top right. Knocked out white gears bleed into the white of the body text to unify the two columnar sections.

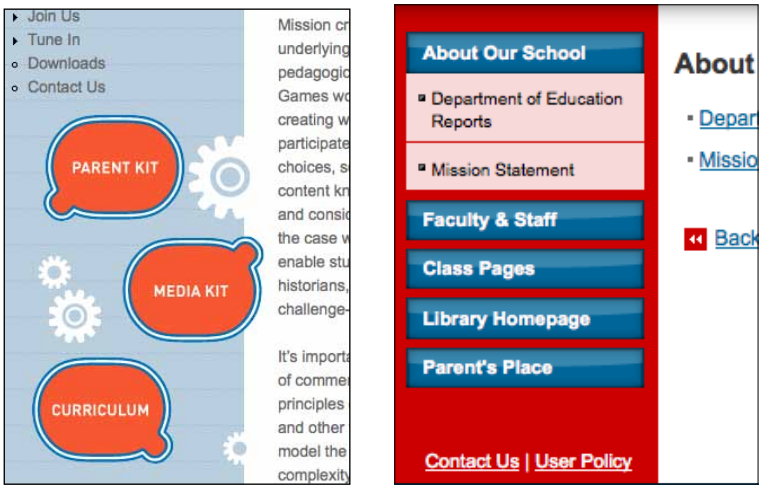

Figure 24. Quest to Learn vs P.S. 63 Web Site Menus ("Quest to Learn: Mission," 2010; "P.S. 63," 2010)

Above is a comparison of the web site menu designs for Q2L and P.S. 63 –The William McKinley School (Figure 26). The menu of P.S. 63 consists of the following colors: red, pink, blue, white and black. When paired together in a color palette red and blue, like orange and blue, are each vibrant in their own right so that when combined, these colors have an overcharged energy. The pink seems out of place and is a superfluous color. If the designer desired a color to distinguish the submenu from the menu, then a color in the same family as the menu (i.e., blue) should have been used. The resulting look is disjointed. Moreover, using red, white and blue is associated with the colors of the United States flag; associating a public school with the country is far too obvious and is

disjointed from any distinguishable brand the school can own. The color palette is a thus a fail times two. The blue buttons have a garish highlight that provides a faux three-dimensional effect. Using a passing design trend is not advisable in building a solid brand identity. Not only is the design of the P.S. 63 ineffective, but it also has no real connection to the school's mission statement (below), which is too broad.

> Our staff recognizes that all children learn differently and it's our job to build on their strengths and determine how to best reach each student. At P.S. 63, we encourage students to become active participants in their education and school-wide community. We believe that this philosophy will guide students on their path to becoming lifelong learners. ("P.S. 63," 2011)

The success of Quest to Learn is very much apparent. It received grants from The John D. and Catherine T. MacArthur Foundation one of the nation's largest independent foundations, and The Bill and Melinda Gates Foundation, which has a primary focus on improving public education. Key supporting partners are The Institute of Play and The New School University. It is notable that Q2L allocated some of that grant funding to visual identity, branding and design. Q2L is growing each year and, because of overwhelming student interest, organizes open houses and tours. It also invites candidates to demonstrate their problem-solving abilities in challenges with Q2 faculty. The school has been so successful in its innovative approach that it is opening a branch in Chicago in the fall of 2011 ("Chicago Quest," 2011). The importance of creating an identity for a school through visual branding is important for educators to realize. It supports and strengthens a school's mission and purpose; it also motivates teachers and students to be a part of a cohesive community.

Problems and Quandaries

Since it is a new and budding field, information design is saddled with complication and uncertainty. Education itself is such a complex field that there are no clear practical applications available for information design. To make matters even more complicated, there is limited understanding by the general public on what information design is and its effective application. Another problem is that creating data visualizations is not easy. One must possess specific types of knowledge (e.g., typography, statistics) and know how to use advanced software applications like Origin and/or Adobe Illustrator. Lastly, the increasing convergence of art and science presents a new field for students and educators to confront.

Education's Relationship with Information Design

The complexity of information design in education can be understood by first looking at three main variables: the school, the teacher and the student. Because of its breadth and reach, information design has deep implications for the field of education. Digitalization and the availability of technology make it possible to source data, create visualizations, and connect with others. There are possibilities that teachers and administrators could incorporate into their schools and classrooms. Thus, it makes sense to consider the larger issues at stake.

The School's Relationship with Information Design

Schools operate as the primary learning space where students and teachers interact. Environment, known as the "third teacher," determines much of the content and methods teachers use in constructing curricula. It refers to details such as display space, spatial orientation and technology. This is important when one considers that K-12 schools typically provide a student's first interactions with computers and design applications. One big problem is lack of funding. Many schools do not have the budget to purchase technology like Apple computers and Adobe Creative Suite. This problem distorts the quality of the relationship between schools and information design.

Another issue affecting schools with relation to information design is the quality of a school's visual identity. With hot issues like assessment and standardized test preparation, visual identity is not high priority for most schools. This is understandable since education is the whole point of a school. There exist many hurdles such as time, money and training, but establishing a visual identity could be construed as a more positive, team-building exercise for faculty who can work with designers in an arrangement similar to Stanford's d.school.

Another aesthetic concern for schools is environmental design and the enforcement of a consistent standard. For example, a school may have many bulletin board display areas in its hallways. Some boards may have plastic storage bags hanging as permanent housing for student essays to be swapped in and out with ease. There may be a board with a bright blue background located next to a board with a hot pink background, which is then situated next to a board with a neon green paper background. Directional signs indicating spaces like the auditorium, teachers' classrooms and laboratories may be of consistent design but not in synch with other signs in the school. Clearly, there is a hodge-podge of environmental design happening in this hypothetical—although likely to actually exist—school. Bringing together disparate visual elements can be a way of organizing the school that

bolsters the development of a visual identity.

The Teacher's Relationship with Information Design

The teacher has an immediate and important relationship with information design, as it is the teacher who locates information and presents it to his or her students. With the increasing availability of technology in the classroom like internet access and SMART Boards, teachers are being confronted with the reality of using electronic modes of communication to present information. Edward Tufte, who conducts professional seminars on presenting information, likens the presenter to a teacher in explaining how "practical teaching techniques are very helpful for presentations in general. Teachers seek to explain something with credibility, which is what many presentations are trying to do. The core ideas of teaching—explanation, reasoning, finding things out, questioning, content, evidence, credible authority not patronizing authoritarianism—are contrary to the [ineffective] cognitive style of PowerPoint" (2006, p. 161). The overlap is undeniable, and it brings up the issue of professional development for teachers, which fails to include information design. Teachers are open to learning and, as such, it makes sense to enable them with the skills and knowledge that would sharpen their use of presentation technology.

The Student's Relationship with Information Design

As the third party in this loose hierarchical model, students are already at a disadvantage by being dependent on the school and the teacher's relationships with information design. This may not be such a huge issue for students who actively construct their knowledge through inquiry and have technological resources outside of school. For students attending a school with limited computer resources, they may be receiving an education that they will have to undo in their post-secondary professional lives by attending an Edward Tufte seminar! Microsoft PowerPoint is the most common presentation tool for general audiences, despite its major flaws and limitations. Tufte (2006) laments that "these PP [PowerPoint] graph templates are particularly unfortunate for students, since for all too many their first experience in presenting statistical evidence is via PP designs, which create the impression that data graphics are for propaganda and advertisements and not for reasoning about information" (p. 159). It is all too tragic to subject students to ineffective information design, but then again, the teachers themselves may not be privy to what categorizes information as ineffective.

Students are engaging with digital technology that enables them to create media and they

may be doing so without critical knowledge of information design, which could otherwise help them create and navigate in more advanced ways. Take, for example, a middle school student who decides to create a web site that consists of a blog documenting what she eats for lunch each day. The typography, color, lines, and other visual elements are not carefully considered so that she may be assembling a barrage of optical clutter. Something as simple as setting the text in 80% black (dark gray) against white is less cluttering than straight black against white. If the vertically stacked menu bar is imprisoned by black horizontal lines that separate the menu text with tight leading, there may be undesirable moiré vibrations. Students may be highly receptive to information design lessons to give them knowledge that would assist them in their original creations.

The Larger Issues for Education

Education policy is complicated and controversial. Suppose a teacher is committed to embracing information design for inclusion in lesson plans. Information design involves graphics-based learning that directly accommodates visual and spatial learning styles. What if some students learn best by reading or listening to text? Then information design becomes less of an aid to fostering student understanding. Is this simply reversing the trend? That is, moving away from reading and listening as dominant modes of instruction. Or is embracing visual and spatial learning a reflection of the state of our culture, which is visually driven and image oriented?

Education is complex. There are multitudes of pedagogical missions and methodologies in the world. Our society is still carrying remnants of the industrial manufacturing age into the information age and so the "banking system" of education—in which students are vessels to be filled with knowledge—persists in select populations. This type of education stands in opposition to the constructivist philosophy in which learning is a process and students construct their knowledge and ideas on top of existing knowledge and ideas. Information design guru David McCandless philosophizes how "in a postmodern perspective, truth is not a single thing 'out there' to be discovered. Instead truth must be assembled or constructed…complexity, diversity, contradiction, ambiguity, and interconnectedness all become central" (2009, pp. 132-33). If "truth" is an end, then educators must face reality that truth must be constructed or assembled by dealing with complexities and ambiguity of life; this presents a challenge for educators who believe in the banking system to some extent and see students as recipients of knowledge. Information design is a way of capturing the messiness of life.

Creating Data Visualizations is Not Easy

It is easy to point to examples of effective information design yet their simplicity belies the complex process behind creating successful visualizations. One big hurdle is that a large body of knowledge is needed so that the designer has an awareness of what works and does not work, and why. Ernesto Villalba (2010) argues that it is important to remember that education does not necessarily beget creativity, but that creative types do have more education because successful creatives have keen divergent and convergent reasoning abilities (p. 324). Needing a vast body of knowledge also means having constant exposure to design theories and data visualizations through books and various media channels: magazines and journals, online newspapers, specialized blogs and web sites, and other sources. There are more creative resources available than students know what to do with; given the choice of 16.7 million colors in a computer screen's RGB palettes, it becomes a matter of informed choice about which colors to use in any given digital creation.

Technological obstacles can hamper a student or teacher's ability to create effective data visualizations. Ideally, professional software like Adobe Illustrator or Origin is used, but understanding these programs requires instruction in a class or tutoring from an advanced user. Moreover, they are very expensive and run from hundreds to thousands of dollars. Another cost is that of typefaces since a computer only comes with a limited number of fonts, most of which are non-professional. The entire font family for a high-quality typeface like Akzidenz-Grotesk costs $450 from the H. Berthold Type Foundry. Typically, schools do have Microsoft Office so that PowerPoint would be the most accessible way of creating and designing, which is a problem. When faced with this dilemma, should educators accept this limitation and teach from an application laden with faults, or should they not teach design at all? There is also the option of bringing pre-computer, paper-style layout and design to the classroom, but this is archaic and not necessarily the best use of teaching time.

Another challenge in creating data visualizations is the need to recognize what is effective and ineffective design. And sometimes data doesn't lend itself to good visualizations, which Professor Brown rightly acknowledges (interview, January 11, 2011). There is no handbook detailing what is "right" and "wrong" in design. Like any art, it is subjective. Certain creative choices like using Arial as a typeface would be akin to using finger paint on canvas instead of oil or acrylic paint. Yet doing so could also be a deliberately ironic statement by the artist. Eventually, effective data visualizations

could become so prevalent that the very poorly designed examples are overshadowed in number. Essentially, the base line would rise. Quality would then have a blurry boundary so that it is no longer easy—or even necessary—to discern effective from ineffective, which would then make it easier for teachers to source examples.

The Intersection of Art and Science

Art and science have long enjoyed a symbiotic relationship. For many centuries medical doctors have been aided by human anatomy illustrations, which gave artists purpose and employment. Now, the digitalization of art made possible by technology has expanded and deepened its connection to science. Scientists who study cells at the molecular levels can go beyond microscopy by working with animators to give detail, life and substance to subjects. One big trait shared by art and science is that they both involve intense seeing. Tufte (2006) points to a "parallelism of Gallieo and Matisse [that] reflects the one deep community of science and art: to show the results of intense seeing" (p. 105). But does "intense seeing" have a place in classrooms? Perhaps so, if there is a life skill to be learned.

The work of Harvard's BioVisions lab has helped to spawn a new breed of scientist-animators who not only understand molecular processes, but have also mastered the computer-based tools of the film industry (Olsen, 2010). Because of the complex knowledge required to be a scientist-animator, one wonders if this career path could be better accommodated so that two separate degrees or schools are not necessary. This raises the questions: should secondary and higher education address these careers or let the scientist-animators navigate the two spheres independently to converge the knowledge within their own minds? Is it possible for the fields to be combined into a science-art hybrid course of study? Doing so makes sense. According to BioVisions, "Research in the biological sciences often depends on the development of new ways of visualizing important processes and molecules. Indeed, the very act of observing and recording data lies at the foundation of all the natural sciences" (BioVisions, 2011). Science is inherently tied to graphic representation as a way of recording data so that in addition to animations, other ways of visualizing data—such as information design—also help further scientific research. The bond is so strong that BioVisions believes that "each decision made on how to represent a given biological process also includes consideration of how best to visually communicate particular aspects of the process" (BioVisions, 2011). Visualizations can communicate scientific ideas; this ability is deemed so valuable that BioVisions lab receives grants

from Harvard, a highly prestigious university, and continues to receive grants from the Howard Hughes Medical Institute (BioVisions, 2011). There is a void in the science field that information design can help fill.

The extent to which digital design will be useful to the sciences looks promising, but since it is still an early stage of convergence, its full value is not yet fully understood. Even the BioVisions lab concurs, "The potential of multimedia in the area of biology education has yet to be fulfilled" (BioVisions, 2011). There is also the question of how the convergence of art and science will enter the classroom and to what extent it can be useful for student learning. The New York Times' Learning Network contains lesson plans based on content covered in articles. One such lesson is based on the work of BioVisions and has students watch high-definition animations that depict the processes of DNA transcription and translation, and then write voice-over scripts; there is also an art-making component where students sketch the cell parts they see in the animations (Cutraro & Ojalvo, 2010). It meets educational standards in language arts, science, technology, life skills, and visual arts, which is an indication of its usefulness for teachers and students.

Chapter V
CONCLUSION

A society centered on production of industrial goods was once effective in implementing standardized curricula to support a Fordist economy. Now, the 21st century demands a different model of education that complements the societal shift to a knowledge-based economy that runs on creative capital. Harnessing society's creativity is therefore necessary for economic success, which means education must confront and evolve curricula and inapplicable learning models.

Preeminent design educator Robin Vande Zande (2010) argues for the incorporation of design education into curricula to counter economic instability, which is being done by several countries such as Finland and China. Vande Zande (2010) goes on to argue that "art education should embrace the teaching of design to build personal growth and satisfaction through application of design thinking to engender ideas for the improvement of society" which also means promoting "the teaching of design as a contribution to the economy" (p. 259). Design thinking, which is centered on innovative problem solving, delivers creative capital; and one essential component of design thinking is information design.

Conclusions and Implications

The goal of this thesis is to investigate how information design, a new field, is being incorporated into different levels of science education from early childhood up through higher education; it also examines how continuing education incorporates information design. Additional questions arose from this research: What kind of demand exists? How are the data visualizations effective or ineffective? What problems and quandaries have emerged from the growth of information design? The research process is recaptured below and is followed by contributions and future research prospects.

Research Process

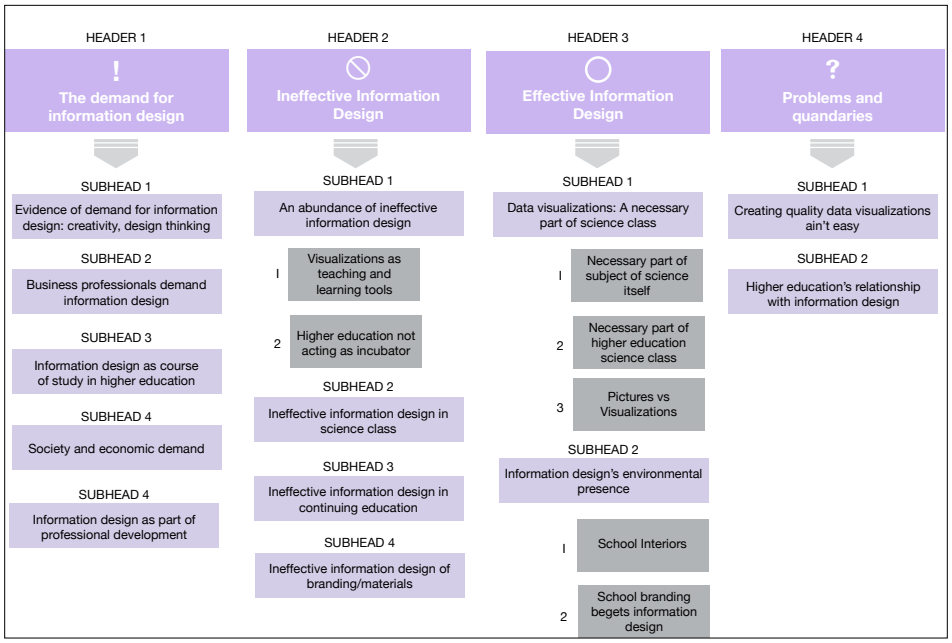

Figure 25. Thesis Research Process Visualization

There were several steps involved in the research process. First, a review of literature was conducted to investigate what the creative class is and how creativity is vital with regard to industry and finance. This lead to an exploration of how the creative economy is valuable: it furthers innovation. The connection between the creative economy and information design was bridged by a consideration of the comprehensive influence of the information age, which necessitates adaptation to massive amounts of information processing. How can society adapt to information overload? The answer: effective information design.

In order to connect information design to innovation, a case was made by providing evidence of the demand for information design in education and society. Business professionals demand information design by attending Edward Tufte seminars en masse. Companies like Column Five Media are starting to find profit in data visualizations. The United States government champions STEM in recognition of the new economy, which RISD President John Maeda more aptly redresses as STEAM so as to include the arts. And there are beginnings of demand in higher education with the development of degree programs like Parsons' Master's in Design Studies, Stanford's d.school, and the glimmers of information design within higher education science classes.

It is clear that information design is in demand. Since science is inherently dependent on visualizations to understand complex concepts, it seemed like a ripe area to study information design. This lead to the question of how it has already infiltrated science education, which required a survey

analysis of the field and focused case studies. The methodology consisted of case studies that were comprised of classroom observations, teacher interviews, and document analysis in science classes at an arts-based higher education institution in New York. This was supplemented by attending professional continuing education workshops: an Edward Tufte seminar, a Parsons Data Visualization symposium, and a Reggio Emilia conference at The Blue School. Since information design is a new field, there is a dearth of scholarly research so much evidence comes from industry experts and articles.

Most notably, this thesis connects science and art by critically examining the new field of information design in light of the economic demand for creativity and innovation. Some of the main findings can be summarized as follows:

- STEM education would benefit from the inclusion of information design.
- There are many ineffective data visualizations and not enough effective data visualizations in science even though available technology enables us to create them.
- An arts-based higher education institution's science classes do not explicitly call for students to create data visualizations.
- Overall, higher education institutions are not acting as incubators for the development of information design, but seem to be moving in that direction.
- Continuing education has begun to recognize the importance of information design.

Contributions

The most important contribution of this thesis is its critical examination of the new field of information design in the specific contexts of education and professional development. In doing so, effective and ineffective examples of data visualizations were isolated and scrutinized. A second important contribution is that this thesis presents a way to embrace the creative economy, through information design, from the critical locus of where higher education flows into the business professional world. Information design mitigates information overload by providing a way to ingest knowledge more quickly, easily, and thoroughly than words alone; it therefore holds value. A third major contribution made by this thesis is how it shines light on the art and design in science vis-à-vis data visualizations. Not enough research or attention has been given to the increasing presence of art in the science field. Lastly, this thesis elaborated on the professional embrace of information design at the continuing education level. Since some business professionals, corporations, and non-profit

researchers have realized the utility of information design, it should naturally trickle down into higher education and, presumably, down to secondary and primary education.

Prospect of Future Research

As information design comes to play a more prominent role in science education, further research is needed. There remain very few academic publications in this area, which leaves many holes to be filled. Since it is a developing field, there are many exciting opportunities for study. One large avenue for study is the convergence of art and science in K-16 education. A related area for study is examining new modes of secondary education using information design. This could be actualized through action research so that, for example, instead of algebra a high school would offer a class called "mathematics information design."

There is also the possibility of studying higher education's response to and incorporation of information design in degree programs, which could include a case study of Parsons' new Master's program in Design Studies. Another looming field for future research is continuing education programs that address information design for science educators.

Lastly, a huge void remains in the subject area of school visual identity and branding for all education levels. The discrepancy between private and charter schools and public schools could be a fruitful starting point. As creativity becomes more apparent as an aid to innovation, information design can achieve recognition as a key commodity, or product, of a knowledge-based society. It is up to policy makers and educators to realize information design's full potential. Information is beautiful and useful.

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