INTERACTIVE SENSORY PATTERNS
IN SCIENTIFIC INFORMATION

DIGITAL REPRESENTATIONS OF PATTERNS

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STACIE ROHRBACH

COMMITTEE

MEREDITH DAVIS
Committee Chair and Professor, Graphic Design

TONY BROCK
Assistant Professor, Graphic Design

DENISE GONZALES CRISP
Department Chair and Associate Professor, Graphic Design

MARTHA SCOTFORD
Professor, Graphic Design

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DEPARTMENT OF GRAPHIC DESIGN, COLLEGE OF DESIGN, NORTH CAROLINA STATE UNIVERSITY

CONTENTS

MEDIA DOCUMENTATION SUPPORTING THIS PROJECT EXISTS ON A CD-ROM LOCATED IN THE BACK OF THIS PRINTED DOCUMENT

Scientific information, such as formulas, equations, statistics, and quantitative data is often unnecessarily presented to learners in the abstract language of text and numbers. This project explores the characteristics of digital environments as a means of representing abstract concepts concretely. Through interaction and exploration, viewers engage in enjoyable learning experiences which enable the natural sensing and feeling of what information means.

The translation of abstract, quantitative data into concrete, qualitative form is achieved by emphasizing patterns (repetitions and similarities) inherent and often hidden in traditional representations of scientific information. Qualitative representations enable the broad understanding of concepts rather than the amassing of details.

Based on a diverse sampling of scientific information as content, six studies have been constructed, which express patterns visually, temporally, and aurally. An analysis of these studies reveals a set of design strategies that facilitate concrete learning. Hence, instead of requiring people to memorize and reflect, they are encouraged to compare qualitatively, analyze critically, and evaluate information through active engagement in their learning experiences.

The visual, temporal, and aural affordances of interactive digital media enhance the communication and understanding of abstract information by engaging viewers in concrete, sensory experiences. However, educators still typically rely on the printed page to deliver content. Unfortunately, static communication often presents complex information simultaneously. As a result, people are commonly inundated with abstract, detailed data which requires reflection, and the patterns in content are invisible. To response to the natural modes of perception and processing which learners prefer, there is an increasing need for research that explores the educational value of representing abstract information concretely by utilizing interactive digital media.

HOW CAN THE INTERACTIVE, DIGITAL REPRESENTATION OF INFORMATION PATTERNS, INHERENT AND OFTEN HIDDEN IN TRADITIONAL PRESENTATIONS OF SCIENTIFIC CONCEPTS, REVEAL A SET OF DESIGN STRATEGIES THAT FACILITATE CONCRETE LEARNING?

To address this question, components of the problem must be considered:

> What is meant by 'pattern' and how can it be expressed visually, temporally, and aurally?

> How can time, motion and sound be used to represent, and appropriately match, the content of abstract concepts in a digital, interactive environment?

> Through interaction, what can a user gain from accessing scientific concepts through visual, temporal, and aural representations, as opposed to textual and/or numerical representations?

The Importance of Understanding Learner Types

In her book, *The 4MAT System,* Bernice McCarthy explains that there are several ways people can and prefer to learn, as well as the disadvantages in addressing only one profile of student. Traditional education often disadvantages students who prefer to learn, and learn best, by perceiving information concretely and processing it actively—by sensing, feeling and doing. Many textbooks explain concepts in an abstract manner—textual and/or numerical in form—and test scores favor students who exhibit strong memorization and reflection skills in response to this data. While contemporary learning materials appear to address active learning, many are simple exercises or media-based experiences that either substitute animation for activity or repackage quantitative data in a more refined form. What is less available is the media-based explanation of scientific concepts that engages students concretely in the meaning and significance of data.

The Value of Patterns

One way to accommodate multiple learner types is to design interactive digital learning environments which enable people to access information in ways that match their learning strengths. Education typically caters to those who are linguistically and mathematically strong, disregarding those whose abilities naturally favor musical learning, for example. Psychologist Howard Gardner defines these innate abilities as "intelligences" and explains that there are several ways to be intelligent. Two intelligences used to solve problems, the kinesthetic which deals with body movement, and the spatial which aids navigation, are both based on sensing, hearing, and feeling patterns. People continually compare new information to their existing experiences, looking for repetition, similarities and differences. The process of detecting patterns—discovering, connecting, and processing meaning—requires the use of all lobes of the brain. (BARKMAN, P.VIII)

"The more parts of the brain we can engage, the more and better connections we can make, and the more effectively our brains work. Such patterning and the subsequent interpretation of meaning are vital to proper development." (IBID.)

"...complex word patterns that require students to discover meaning engage more parts of the brain than those that have no discernible patterns of meaning. By giving students complex patterns to discover and interpret, we engage more parts of their brain, thereby building more of the connections so vital to higher learning and critical thinking skills." (IBID.)

Therefore, not only can design facilitate critical thinking through pattern finding in the representation of information; it can also make the learning process more congruent with people's natural tendency to look for patterns.

The Affordances of Digital Media

The representation of pattern in educational materials typically appears in static, printed form. Print-based media force complex informational relationships to be interpreted simultaneously which often diminishes the understanding of core concepts. In order to understand such content, people tend to dissect what they see, focusing on details rather than on large concepts.

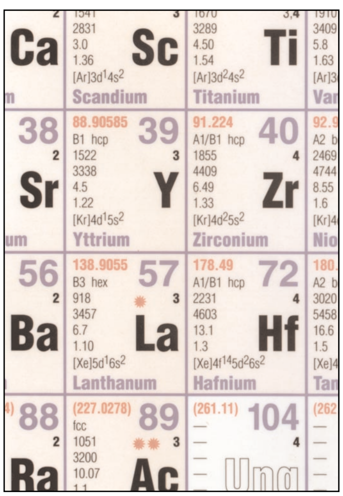


figure 1

The communication of complex information through print typically relies on textual and/or numerical representation because of its compactness *(figure 1)*; as a result, abstract theories and concepts must be intuited from data. Such representation also encourages people to reflect on what they see, rather than to engage actively in learning, because substantial interaction is difficult to facilitate in a static form. Therefore, print often fails to utilize many people's natural tendencies for learning.

In contrast, digital media elaborates on print-based conventions by providing the use of motion, time, and sound to communicate ideas. Not only are people drawn to things that move and emit sounds, many comprehend a greater amount of information through these additional channels than through static representations. Engaging multiple senses in the learning process also increases the likelihood that people will understand and retain more information. (BROUWER-JANSE AND HARRINGTON, P.18)

"...one can immediately apprehend the complex changing patterns etched on fields of wheat or on the ocean by wind. We easily process the complex motions of individual bees in a swarm. We guide our own locomotion using complicated patterns of flowing motion." (IBID.)

Time, motion, and sound provide forms of description that are absent in print. Characteristics that are invisible in static representations of information, such as the weight of objects and/or their speed, can easily be understood through a series of movements. Since people can alter motion and sound in their natural environments, similar interaction in digital spaces can become meaningful. Therefore, abstract concepts take on concrete, experiential forms through the use of digital environments.

EXPERIENTIAL: *based on activity—the personal involvement in and observation of an event—which is felt*

Digital media empowers designers and viewers with choices. Interactive environments enable people to access complex information incrementally, building and unfolding data over time. Layering information is an option, making the simultaneous comparison of content a voluntary, participatory event. As a result, the amount of information overload placed on viewers is less because all content is not visible at one time; viewers are able to study components of data individually or as a group. Digital environments also allow designers to structure complex information in the form of a narrative. Viewers receive the information they need at specific points in time, temporally constructing a story. Consequently, viewers are introduced incrementally to complex content and have time to reflect and understand the structure of the interface in use. Designers and educators need to explore conveying complex information digitally and interactively because of the substantial advantages digital media offers over print.

To reduce the number of variables in digital representations of data related to physical phenomenon, this project uses as content scientific information that typically appears in a textual and/or numerical form. It focuses on information that often is not immediately apparent, seldom connected, and/or difficult to visualize.

CONCRETE LEARNERS: *prefer to learn, and learn best, by sensing, feeling and doing*

Although it is one step removed from doing, this project provides simulations of concreteness which is different from other uses of digital media.

This project addresses 'concrete learners' as defined in *The 4MAT System* by learning theorist Bernice McCarthy, as a reference point for addressing perception and processing needs that are frequently ignored by the design of learning materials. However, any approach is beneficial for a larger range of learners and the study examples are not limited to a particular group of individuals. The content is written for college-level students.

Although interests for future study, this project will not address the acquisition of knowledge through making, or the potential for collaborative learning through pattern finding.

Since the content of the study examples is fairly complex, I assume that viewers have a basic understanding of the concepts being presented. For example, when explaining the patterns found in the periodic table of elements, viewers already understand the definition of an element and are familiar with computers and interactive media delivered via the internet or a CD. Neither do I question the factual nature of the scientific information that I use as content.

By utilizing the patterns inherent in existing scientific data and the affordances of digital media, I created six studies that communicate pertinent information to viewers by engaging them in concrete, intuitive, and sensory-based learning experiences. Created sequentially over a period of several months, I found that each study informed the next in terms of content and approach. Throughout the process, I discovered areas that I hadn't addressed and needed to tackle. As a result, I explored data which contained a diverse set of characteristics and offered a vast range of issues.

The studies are listed in the order they were created and are referenced numerically throughout the document and in the appendix. The studies interpret:

1. abstract, quantitative data inherent in the periodic table of elements;
2. scientific phenomenon—specifically inhaling helium—that is schema-based and involves an invisible process;
3. quick movements found in animal locomotion that may be difficult to observe and slow down;
4. cell division, which is characterized by continual transformation and components that are invisible to the naked eye, but are frequently only depicted in key stages;
5. global warming issues, which contain direct and indirect cause/effect relationships and evoke emotional responses;
6. juxtaposed disparate parts created by comparing biological and mechanical processes.

SCHEMA: *"conceptualized as a mental structure which contains general expectations and knowledge of the world."*
(AUGOUSTINOS AND WALKER, P.32)

Using each of these topics as content for investigation, I explored multiple ways of visually, temporally, and aurally representing information patterns in interactive digital environments. As part of my investigation, I created and examined a range of methods for representing, experiencing, and interacting with information.

My goal in conducting these studies was to develop design strategies that, when applied to complex content, aid people in understanding abstract, textual, and numerical information in a concrete, sensory manner. The similarities and differences I discovered among the studies enabled me to build four strategies. Although I found connections and overlaps among the content of the strategies, which I explain in greater detail in the *Conclusion* section, I believe it is important to discuss each topic separately to gain a clear understanding.

> *Pattern and Detection* describes the types of patterns people recognize and construct, and identifies the components necessary to create environments that encourage pattern discovery and perception.

> *Representation* deals with the visual, temporal, and/or aural forms used to stand for something else. Static and dynamic content treatment and structure are addressed, as well as the need to consider project goals and viewers' expectations throughout the design process.

> *Interaction and experience* are dependent on representation decisions. The *Interaction* strategy focuses on the affordances of customizable learning environments and the ability to create meaningful interactions by mimicking the known behaviors and actions of viewers.

CINEMAGRAPHIC: *visual, temporal, aural, and/or spatial qualities of motion pictures which engage viewers in stories*

> *Experience* draws attention to cinemagraphic qualities that foster the imagination of viewers and encourage discovery and critical thinking in both interactive and non-interactive digital learning environments.

In explaining the strategies in greater detail in the next section, specific parts of relevant projects are referenced and described. Information regarding the origin, motivation, context, and process of each study can be found in the appendix of this document. Images and captions which explain each project in detail accompany descriptions.

Patterns can be defined as "observations that are organized into meaningful information to the observer." (BROUWER-JANSE AND HARRINGTON, P.XI) Missing from this statement is the role people play in constructing that meaning. Everyone naturally seeks and creates order in the world, juxtaposing and comparing information. People also compare new information to their existing knowledge—specifically schemas and stereotypes—by connecting similar and repeated events. In his book, *Experiences in Visual Thinking*, Robert H. McKim argues that people do not passively see and perceive information. Instead, he explains that "perception is an active pattern-seeking process that is closely allied to the act of thinking." (MCKIM, P.14) Gestalt psychologists describe this act as a force that draws imagery together to form patterns.

People engage in this process by performing closure. McKim explains this as a two-step procedure. First, people fill in incomplete patterns and then find patterns that may be buried in surrounding imagery. The act of perceiving patterns is necessary to understanding complex concepts.

The grouping of information in a complex array is both voluntarily and involuntarily. The mind naturally organizes information by proximity, similarity and line of direction. (IBID., P.61) It structures information voluntarily by performing such cognitive acts as forming outlines, grouping collected data, and unifying visual elements. It seems logical, therefore, for designers to make patterns visible, providing a heightened awareness through which people perceive and process information. However, designers must first understand what constitutes a pattern and recognize the importance of creating conditions that enable pattern discovery.

Types of Patterns

The digital environment provides design affordances that are not available in print. Not only can information be conveyed visually, but sound and motion can add to the interpretive palette. These tools can effectively translate quantitative information into a qualitative form, making inherent patterns more recognizable and conveying additional information about the meaning of specific content.

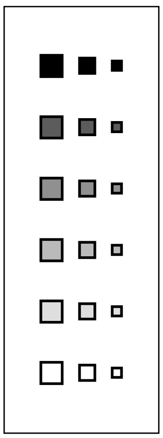


figure 2

Visual, temporal, and aural repetition can be understood as pattern, either separately or in combination with one another. Each of my studies utilizes patterning mechanisms in varying amounts. For example, one study *(project 1)* explores the affordances of digital media by enabling people to decide whether to layer information patterns simultaneously or view each separately. Pattern is apparent by representing content characteristics, such as variations in mass, in a qualitative form. One characteristic is described by variations in scale. A second is indicated by varying speeds of motion, and a third is defined by pitch shifts. (Motion and sound cannot be utilized in a print-based environment. Therefore, scale and value are used to illustrate this concept in *figure 2.*) In contrast, another study *(project 6)* explores the overlap of visual, temporal, and aural patterns, causing viewers to cross-reference and interpret relationships between them.

Number and Hierarchy

Although people may comprehend a greater amount or complexity of information through motion and sound than by static means alone, it is important to recognize the mind's limitations for pattern recognition. Designers need to deal with people's inabilities to comprehend large numbers of differences.

> *"Using similar visual units, we have an assured numerical response up to a variable threshold in the vicinity of seven or more. Beyond that number a rapid deterioration in accuracy leads into the concept of plenty."* (BARRATT, P.26)

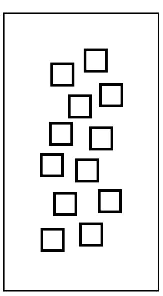


figure 3

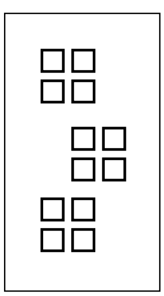


figure 4

In his book, *Logic & Design*, engineer and artist Krome Barratt argues that when the number of objects exceeds seven, it is wise to use grouping procedures in order to facilitate differentiation. He explains that forming groups of groups, based on similarities, provides order. People perceive information sequentially and, therefore, need a method of guidance that enables them to scan quickly. Barratt describes this assistance as a flowpath that is largely dependent on sequence and hierarchy. (IBID., P.28) Therefore, logically related objects that appear in a clear order are easier to grasp *(figure 4)* than those that fail to meet these principles *(figure 3).*

I utilized and tested Barratt's notions in the creation of the periodic table study. *(project 1)*. Working with 118 different elements, each of which has its own set of unique characteristics, I found it necessary to establish a set of similarities and represent them in a form that enables people to compare information and perceive the larger systems at play, rather than focus on specific details. Based on the concrete values established for each element within a particular category such as reactivity, I separated them into seven groups. Each group contains elements that are similar in amount and each element is represented visually, temporally, and aurally employing sequential and hierarchical principles.

In doing so, I discovered clear delineations among groups, making it difficult to see the progressive changes that occur throughout the table. Reducing the number of variables does, however, facilitate a better understanding of the whole rather than its parts. Wanting to emphasize the table's slight variations, I increased the number of groups to fourteen. When viewing the table at this point, the identity of specific groups appears hazy, revealing a steady progression. But more importantly, in this case, patterns are still clearly visible and the progression of change is more gradual *(figure 5)*.

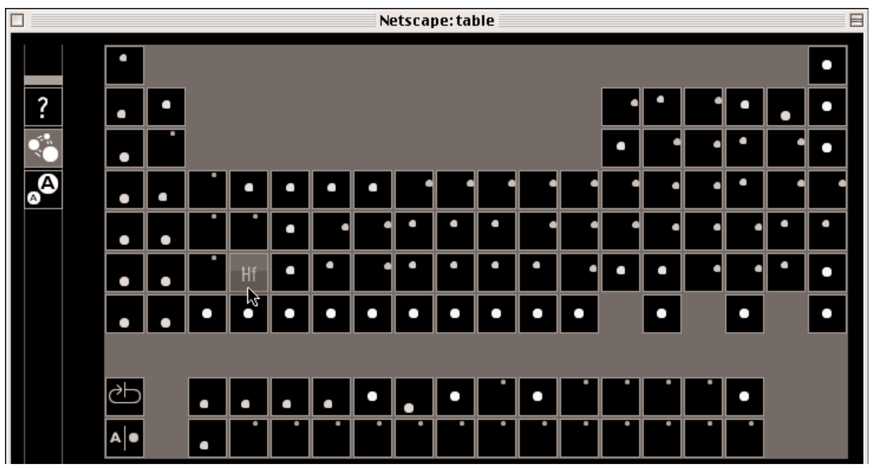


figure 5

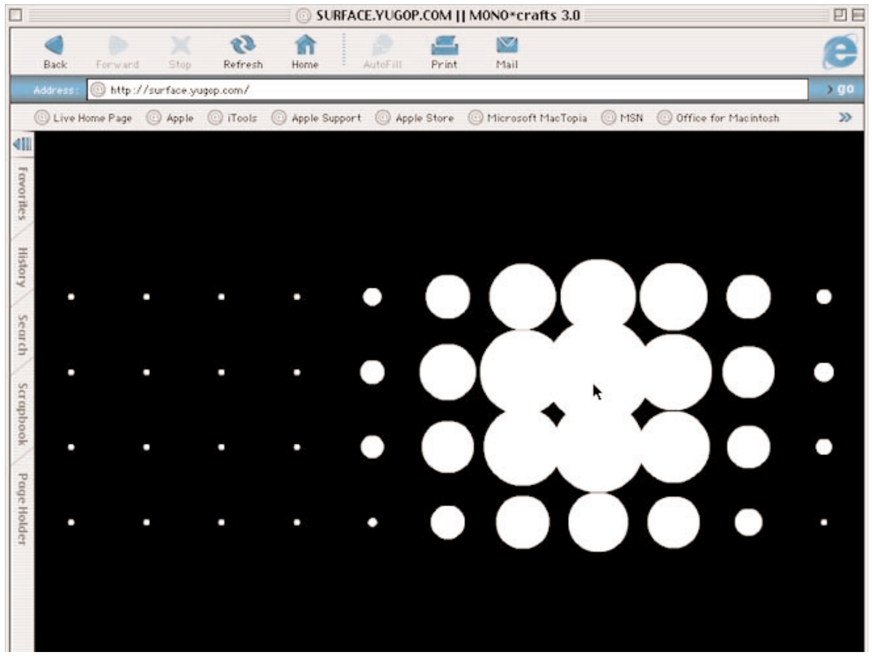


figure 6

Web sites that employ a similar system of hierarchy appear throughout the internet. For example, several studies presented on *<http://www.yugop.com>* use limited visual and motion variables applied to simple graphics to help viewers understand the concept of parts to whole. The studies focus on mouse interaction and how it can provide visual, sensory feedback. In this case, the content seems fairly arbitrary *(figure 6).* Unfortunately, these principles are not usually applied to complex information. I believe the periodic table study *(project 1)* indicates the potential for such application and illustrates the importance of limiting variables.

Temporal Building

A complex body of information needs to be broken into logical groups to facilitate quick and easy perception of concepts. In their book, *Wet Mind,* neuro-scientists Kosslyn and Koenig explain the necessity for people to build categories by inspecting images.

> *"Part of what it means to 'have an image' is to be able to interpret the imaged pattern. If one could not 'inspect' patterns in images, for all intents and purposes, they would not exist—and hence imagery would be useless for recalling information."* (KOSSLYN AND KOENIG, P.133)

Viewers recognize patterns more easily by inspecting complex images one after the other, rather than simultaneously, because changes in images become visible through temporal transitions. People compare subsequent images to their predecessors, finding similarities and forming categories.

Comic book artist, Scott McCloud expands on the concept of transitions and their value in his book, *Understanding Comics*. He explains that there are several types of transitions that occur temporally—moment-to-moment, action-to-action, subject-to-subject, etc. Connecting the frames sequentially forms a story. The importance of these transitions is that they require viewer participation; people must understand the first image in order for the second to make sense. Some transitions require more thought than others, however the building principle remains.

Layers of complex information that are revealed sequentially, rather than simultaneously, function similarly by providing viewers the amount of time they need to discover and perceive patterns. Understanding a large volume of information is difficult when presented simultaneously, but becomes much easier when it is introduced in smaller amounts over a period of time. Therefore, I believe patterns need to be built incrementally to enable their detection and understanding.

I tested this notion through a project based on Eadweard Muybridge's study of animal locomotion *(project 3).* When horses are in motion, the changes in their leg movements, center of gravity, head position, etc., form patterns. I constructed a set of flip books which illustrate these patterns statically on printed pages and become kinetic by quickly flipping through the books. Some of the books contain only a single variable, such as the changing placement of feet. *(figure 7)*. Others include multiple units of information, such as the changing position of the horse's head, its jockey, and the background *(figure 8).* It is important to note

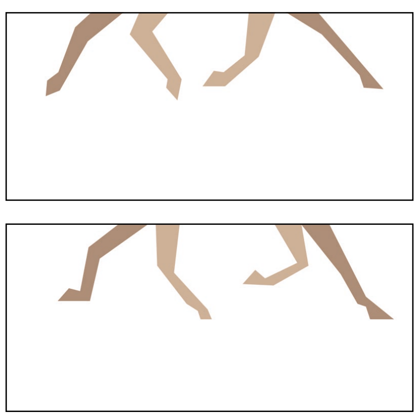


figure 7

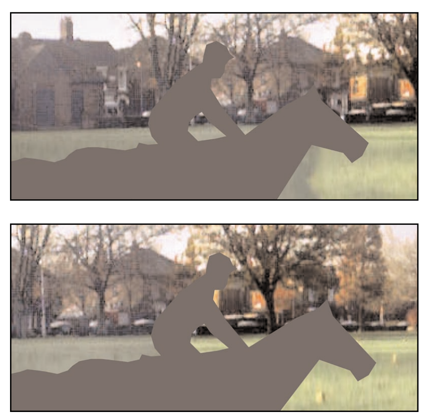


figure 8

that the patterns illustrated in each book are shown on the first page and continue throughout the entire book. Therefore, the patterns do not grow in complexity over time, but they do change in state. Through observation, I discovered that the books that contain several variables make the detection of all of the patterns difficult, whereas those that have one change enable easy recognition of distinctions among movements.

In contrast, the biology/machine study *(project 6)* explores the value of introducing patterns over a period of time. The project begins with the presentation of a simple visual pattern, illustrating the transfer of energy through a machine, which is reinforced by aural repetition *(figure 9).* Repetitive sounds and consistency in frequency can be perceived as patterns, either separately or combined. For example, the sound of the machine repeats constantly. However, it slows over time as energy is expelled from the machine. Although the frequency changes, the sound does not. Therefore, the pattern is still easily recognized. Additional patterns describing the similar uses of energy by plants are introduced and transformed throughout the duration of the piece *(figure 10).* The communication of ideas remains clear because viewers are given time to perceive the messages as they receive them temporally. The study solidifies the notion that patterns built over time are often easier to comprehend than those shown simultaneously.

figure 9

figure 10

In artistic terms, representational refers to a likeness, a picture, or a model; as, a representation of the human face, and the like; i.e. photographically representational. Abstract is antithetical to this definition.

Representation can also be a presentation to the mind in the form of an idea or image, which is the definition I am using.

Representation, the visual, temporal, and/or aural form used to stand for something, can be shown dynamically, illustrating change over time as well as the physical components themselves. Visual representations can convey information statically, without any movement. It is important for designers to consider project goals and viewer expectations when determining effective and appropriate ways to treat and structure information.

Qualitative information provides general ideas or a sense of meaning in topics (connotations), while quantitative information emphasizes specific amounts (denotations). Since this project focuses largely on sensing a "perception of the whole" through patterns, rather than comparing details about individual components, qualitative approaches seem appropriate and valuable. It is important to understand how quantitative data can be represented accurately but also provide concrete, sensory-based understanding of numbers and amounts.

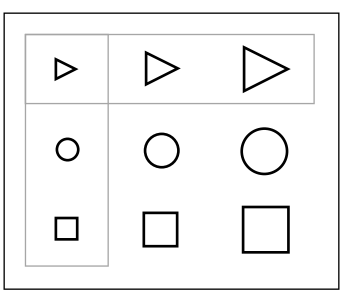


figure 11

Categorization and Appropriateness

Grouping data that share similar characteristics in relation to the larger system can assist representation. Position within the structure is typically based on gradual differences in characteristics that are shared among the members of the group. For example, the objects in *figure 11* can be organized categorically according to their shape. Objects can also be positioned hierarchically based on their size. In his book, *Information Anxiety 2,* information designer Richard Wurman describes the task of grouping as organization. He explains, "The ways of organizing information are finite. It can only be organized by location, alphabet, time, category, or hierarchy." (WURMAN, P.40) I would add the comparison of information by parts to whole to his list.

"While information may be infinite, the ways of structuring it are not. And once you have a place in which the information can be plugged, it becomes that much more useful. Your choice will be determined by the story you want to tell. Each way will permit a different understanding of the information—within each are many variations. However, recognizing that the main choices are limited makes the process less intimidating." (IBID.)

Wurman explains the importance of clearly identifying goals. For example, designers and educators may find that providing students with facts and figures is not the only goal in presenting scientific information. The quality of representations is as important as content or an inventory of constituent parts because form affects how viewers interpret information. Concrete attributes, while possibly exceeding the needs of the task at hand, may improve comprehension and retention of concepts by triggering connections to larger analogous experiences.

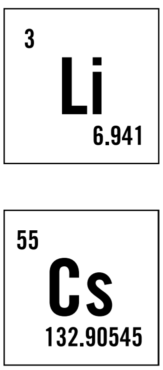


figure 12

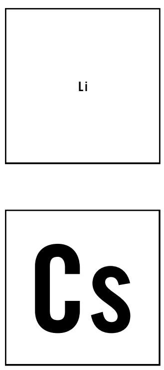


figure 13

Therefore, large concepts become easier to grasp when groups of data are represented graphically, temporally, and/or aurally rather than more abstractly in a textual or numerical form. For example, in *figure 12,* numbers, which are abstract, indicate the atomic mass of two elements. *Figure 13* illustrates how those values can be translated into graphic forms that describe mass concretely through scale. In a digital environment information can also be described by changes in:

> pitch: the level of sound an object makes
> location: the position of objects on a screen
> proximity: the location of objects in comparison to others
> quantity: the number of objects visible or sounds heard
> duration: the amounts of time objects are visible or sounds are heard
> direction: the object's quality of movement from one point to another
> attraction/repulsion: the movement of objects in relation to one another
> speed: the rate at which objects move or sounds are heard
> frequency: the number of times objects appear or sounds are heard

The use of these conventions may also reduce the need for a written language in describing concepts that may make communication more universal. I have used many of these conventions throughout my studies; some have been more successful than others have, which raises the issue of appropriateness.

Wurman touches on the idea of appropriateness by stating that forms of representation affect the understanding of information. Donald Norman describes it in greater detail in his principle of appropriateness, arguing the necessity for information to be quickly and easily understood and matched to the task.

"The representation used by the artifacts should provide exactly the information acceptable to the task: neither more nor less." (NORMAN, P.97)

The understanding of qualitative concepts can also be part of the task, which Norman fails to address. For example, scale change and the duration of representations can provide important information. Unfortunately, the sensing and feeling of information, which can be emphasized in a dynamic medium, are often devalued in determining representational forms. And although I believe providing a quick reading of content is important, I think the discovery of information is also valuable. These ideas are discussed in greater detail in the following sections.

Exploring a range of representations in my projects has enabled me to understand the importance of appropriateness. In constructing the periodic table study *(project 1)*, I found changing the scale of element abbreviations to be an effective way to indicate mass because the correlation of mass to size is not a big conceptual leap for people to make *(figure 14)*. Plus, the representation of information conveys content by utilizing inherent attributes rather than adding unnecessary components. However, I used red and blue to describe greater and lesser amounts of electronegativity

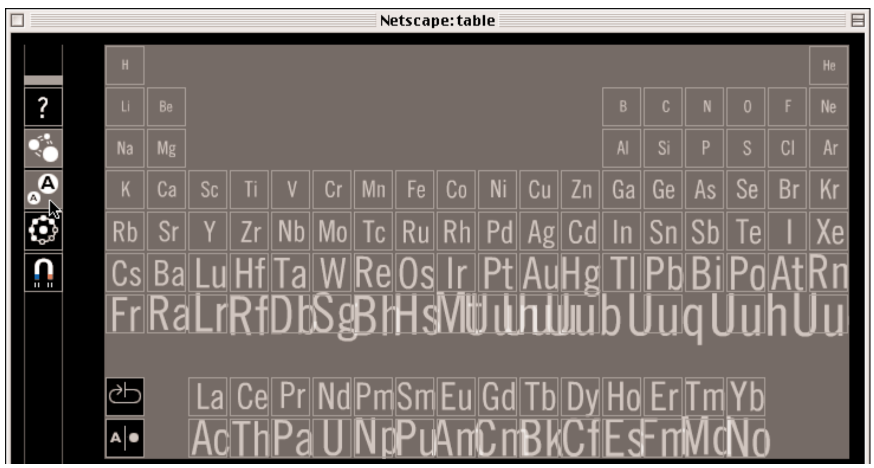
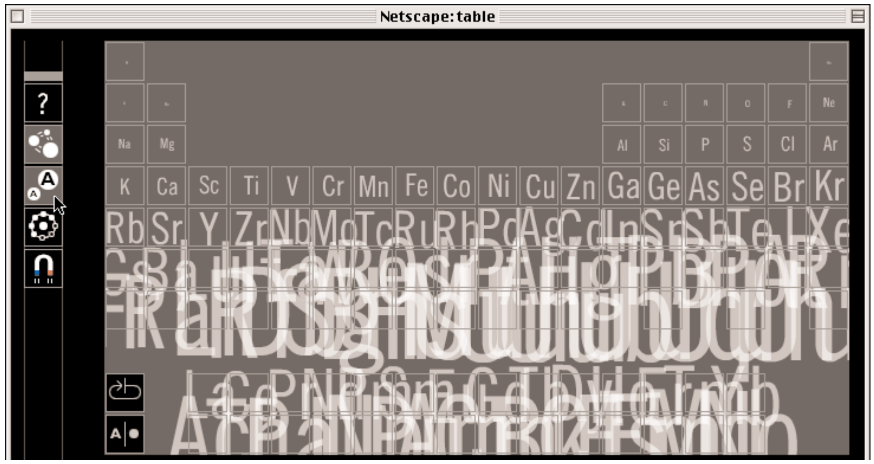


figure 14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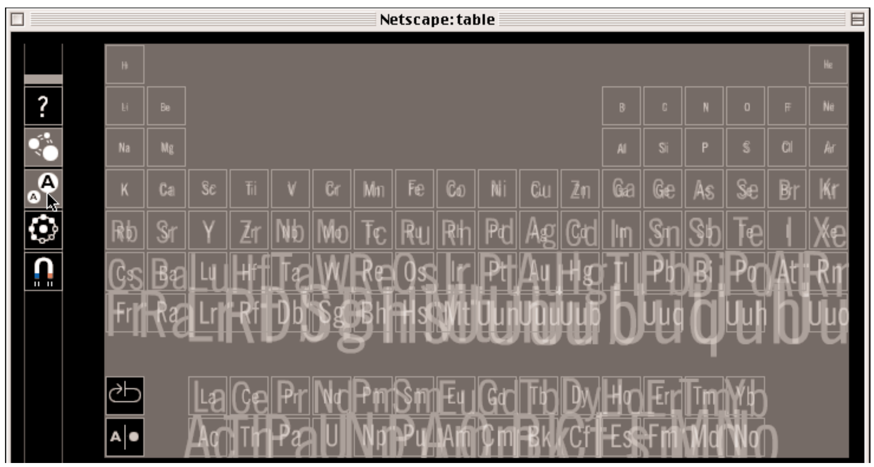
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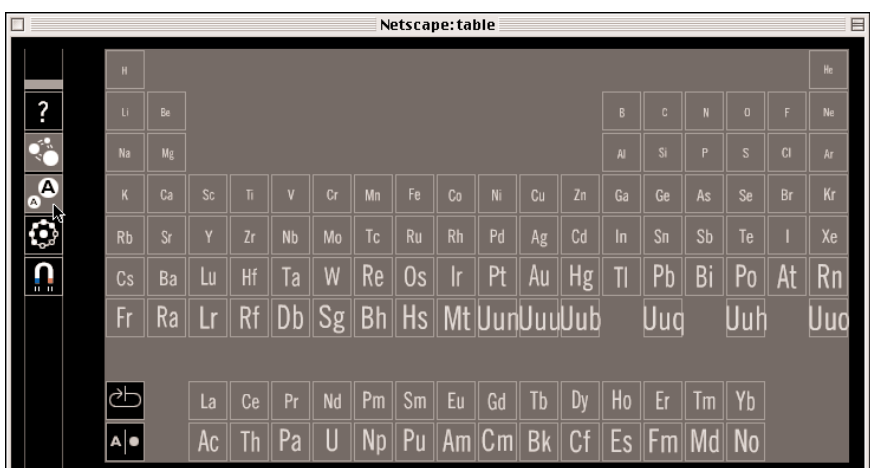
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H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba Lu Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra Lr Rf Db Sg Bh Hs Mt Uun Uuu Uub Uuq Uuh Uuo
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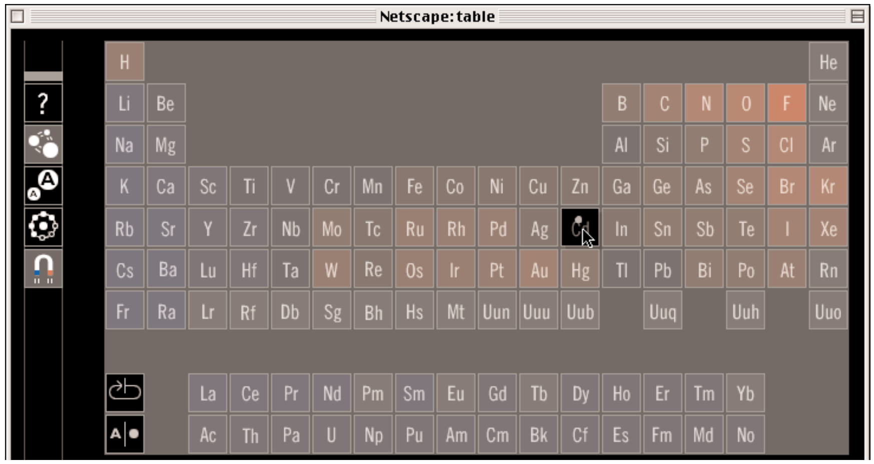


figure 15

which seems less successful *(figure 15)*. Warm and cool colors may be connected to higher/lower, greater/lesser more easily than green and purple. But since people do not typically equate specific colors with amounts, this system requires viewers to learn the code of the representation whereas, using scale to describe mass enables a more immediate and natural mapping of form to content.

> *"Experiential cognition is aided when the properties of the representation match the properties of the thing being represented."* (NORMAN, P.72)

ABSTRACT: *intellectual and affective artistic content that depends solely on intrinsic form rather than on narrative content or pictorial representation*

LITERAL: *avoiding exaggeration, metaphor, or embellishment; factual; prosaic*

Abstract and Literal Representations

Information can be represented literally by mimicking material objects and/or sounds, or abstractly by using qualities, states, and actions in place of real things. However, neither form of representation dictates the type of perception used in comprehending information. In fact, information that is represented abstractly can still provide ways for people to sense and feel information, encouraging concrete perception and analogies to things in the real world that share concepts. I used abstract representations in several of my studies, such as the periodic table project previously referenced, to convey scientific concepts concretely.

Appropriateness needs to be considered when determining whether abstract or literal representations best accomplish the interpretive task at hand. For example, the global warming study *(project 5)* uses familiar images, such as a person pumping gas and water running from a faucet, to explain the effects of fossil fuels on water supply (*figure 16*). These images represent everyday activities more accurately than do abstract symbols, letters, or numbers. As a result people are better able to grasp the effects of global warming by connecting what they see and hear to familiar situations.

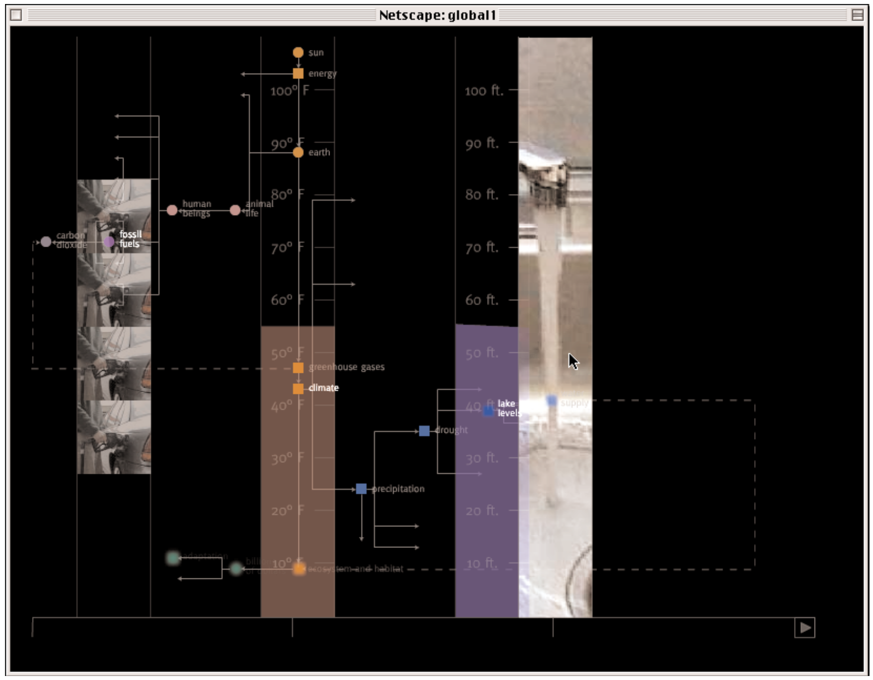


figure 16

I discovered an unsuccessful use of literal representation in a biology book, which attempts to explain the process of cell division through photographs *(figure 17)*. However, the components of the cell are difficult to see, making the images useless for anything more than seeing an actual cell. In creating the study *(project 4)*, I found it most useful to simplify the components of the cell as abstract shapes, enabling comparisons to be made throughout the viewing process *(figure 18)*.

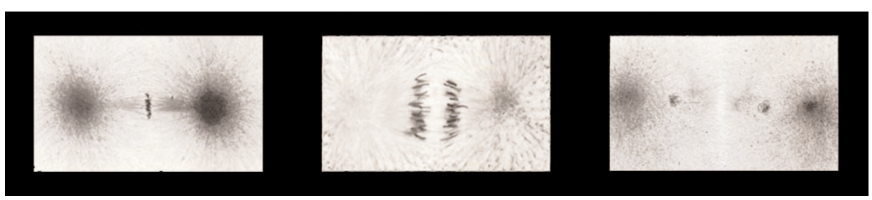


figure 17

figure 18

While exploring ways of describing each category of information found in the periodic table *(project 1)*, I experimented with literal representations and found them problematic as well. I videotaped a person pouring vinegar into a glass filled with baking soda, in order to explain how reactivity functions *(figure 19)*. Upon contact with the vinegar, the baking soda bubbles to the top of the glass and overflows. Although the glass fills the frame of the video and the reaction can be seen clearly, the content of the video—the glass and the liquid—draws more attention than the process taking place. People can't relate to the visuals in this context and hence question what they see. Is the powder an antacid? Is the blue liquid a detergent? Therefore, for the purposes of this project, the literal representation of a reaction didn't communicate reactivity successfully.

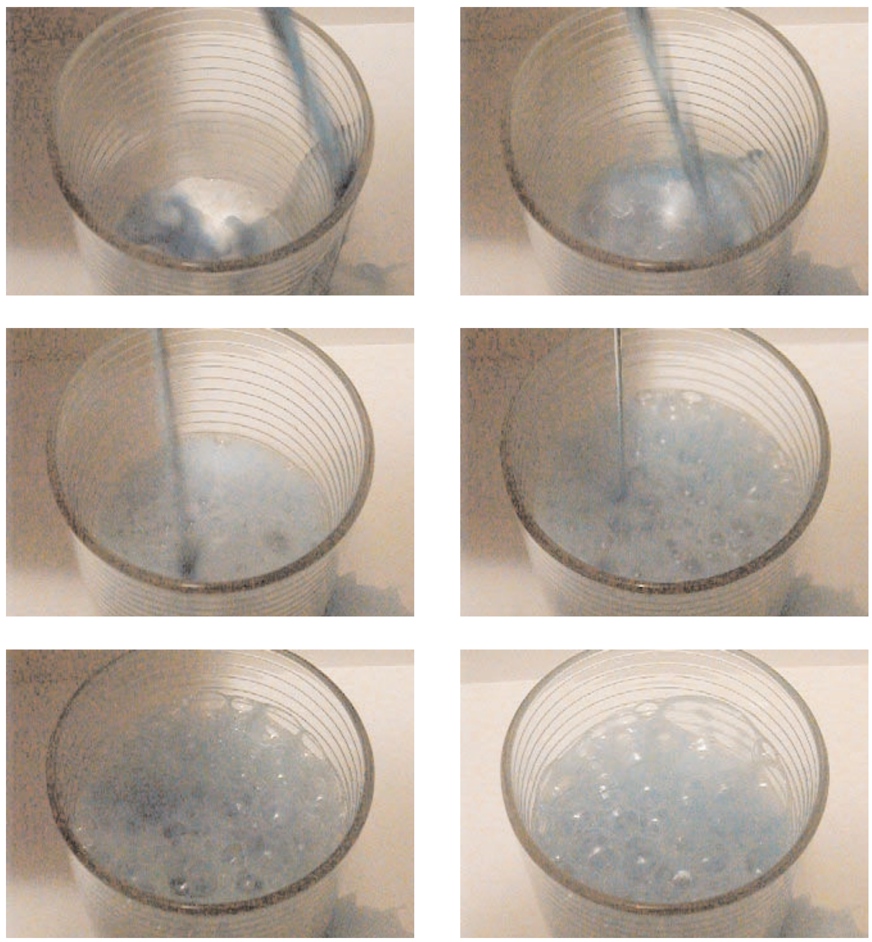
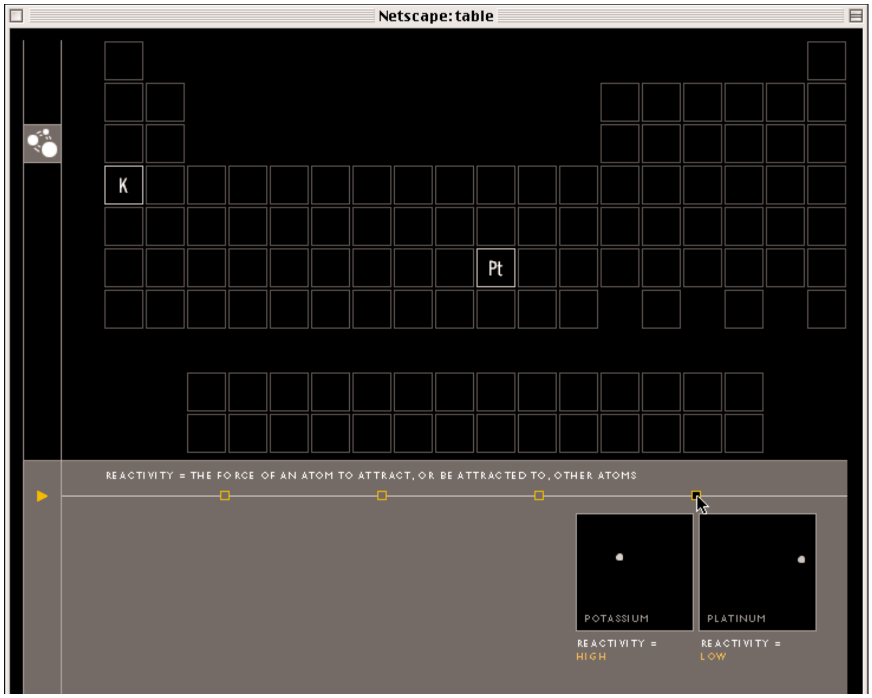


figure 19



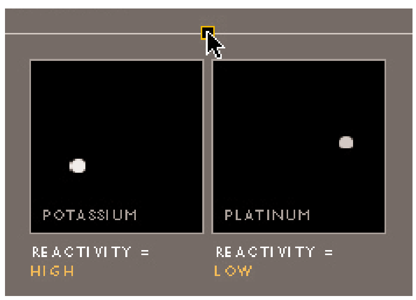


figure 20

I then explored the use of abstract forms to represent reactivity effectively. By analyzing the baking soda study, I discovered that a quick change in state or movement characterizes reactivity. For example, vinegar poured into a glass of water doesn't produce the rapid change apparent in the vinegar and baking soda study. I used a simple shape and a range of speeds to describe reactivity (*figure 20*). Most people correlate speed with levels of activity. Hence, slow moving objects indicate less reactivity than fast moving objects. I chose to use circles in the project because they do not draw as much attention as the glass, so people are able to focus on the actions being performed. Since still circles don't carry specific meaning, their movements convey concepts. A similar-looking static icon which helps people connect the two representations reinforces the activity. Therefore, when viewers see the static icon throughout the study they are easily able to recall the temporal representation of reactivity previously shown. By creating several studies that explore abstract and literal forms of representation, I see the merit and necessity for both but also understand the importance of considering appropriateness.

Point of View

In *Women, Fire and Dangerous Things*, philosopher/linguist, George Lakoff explains that people store information categorically in their minds and sort and recall experiences and concepts based on these categories. Therefore, the more closely digital interfaces can match concrete things, either in representation, interaction, or experience, depending on the goals of the project, the more easily related categories can be triggered.

It is important to take this concept a step further. Not only is it valuable to integrate familiar objects and actions into the representation of ideas, but the point of view captured must also be considered because it influences interpretation. For example, when communicating what a child sees, it may be less descriptive to see a child looking at an object on a table than to present his view of that object at a camera height that matches his eye level.

The importance of point of view can clearly be seen in the helium inhalation project I constructed *(project 2)*. In the first iteration, two people are represented by black graphic bodies *(figure 21)*. Mouse interaction causes sound waves to be emitted from one figure in the direction of the other. The repetition of interaction forms a visible pattern and the concept of helium carrying sound waves through air faster than normal, due to its lighter weight, is clear. Unfortunately, the experience is not engaging because the representation of the people does not directly relate to a situation most viewers recall or expect. As a result, the representation does not invite viewers to recall any sensory impression from past experiences and the meaning is decontextualized.

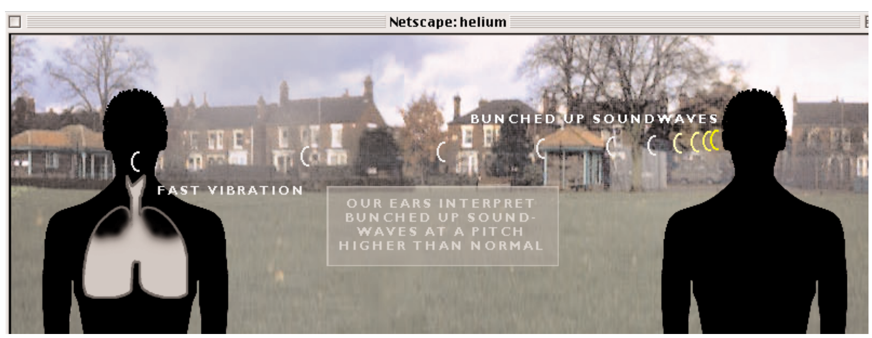


figure 21

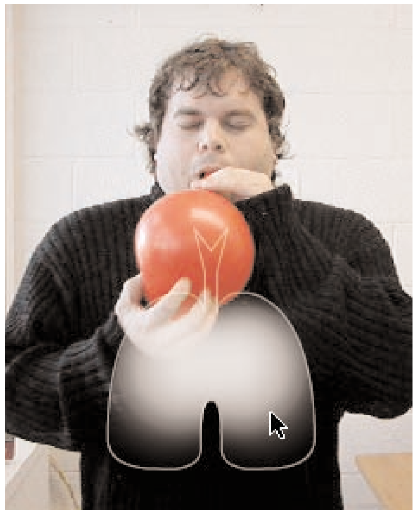


figure 22

Realizing the flaw in the project several weeks later, I created a second version that places viewers directly in front of a person inhaling helium *(figure 22).* The sounds and the actions of the man mimic those that people most frequently store as memories of prior, similar experiences. In this case, multiple channels of information function as reference points, triggering the recollection of memories. Recalling the experience of inhaling helium in a fully sensory way through mouse interaction makes these connections even stronger.

figure 23 (MCCLOUD, P.74)

figure 24 (IBID.)

Pacing and Simultaneity

> *"Pacing, like motion, is an element as critical as the subject matter itself. Alfred Hitchcock used timing and pacing in a film to create suspense in ways previously not conceived. Music videos use time and motion to create moods and influence emotions."* (SHEDROFF, P.290)

The importance of pacing in digital communication cannot be overlooked. Previously mentioned are Scott McCloud's definitions of the types of transitions that can occur temporally: moment-to-moment, action-to-action, subject-to-subject, scene-to-scene, aspect-to-aspect, and non-sequitur. Each of them uses pacing differently to convey meaning. For example, telling a story moment-to-moment *(figure 23)* takes up a lot more time in visual screens than scene-to-scene changes *(figure 24).* Not only are moment-to-moment transitions cumbersome, they are also often unnecessary. Designers need to question how much information their viewers need to interpret messages. Designers may be able to tell their story in two frames versus twenty. Therefore, issues of condensed and expanded time and the effective use of each must be considered.

Not only do the number of transitions affect communication, the duration and simultaneity of information alters messages as well. People's ability to read information presented in a dynamic form becomes more sophisticated as the delivery method becomes increasingly common. In fact, young viewers are so animation-savvy that they often require dynamic media continually to exceed their expectations in order to sustain their interest. In constructing meaning, it is important for designers to be critical of the speed at which their communication moves and the amount of information they are presenting at any given point in time. Is it necessary to read specific areas of text? Are there points where reflection is needed before moving on to other concepts?

The effects pacing and the layering of information have on the legibility and understanding of content became clear while creating the periodic table study *(project 1)*. Due to the complexity of the data, I found it particularly necessary to present information in a carefully choreographed order to enable viewers to progressively connect concepts *(figure 25)*. Upon entry, to the study people receive a common text-based definition for a specific characteristic, such as atomic mass. The definition is connected to an icon that identifies atomic mass throughout the interface. As the icon disappears, two elements are highlighted and referenced below the table. Their form changes over time to explain concretely the representation of atomic mass. The icon appears, once again, reinforcing the connection between the kinetic and static representation. In this case, the order, pacing, duration, and simultaneity of information clearly affect the way content is interpreted.

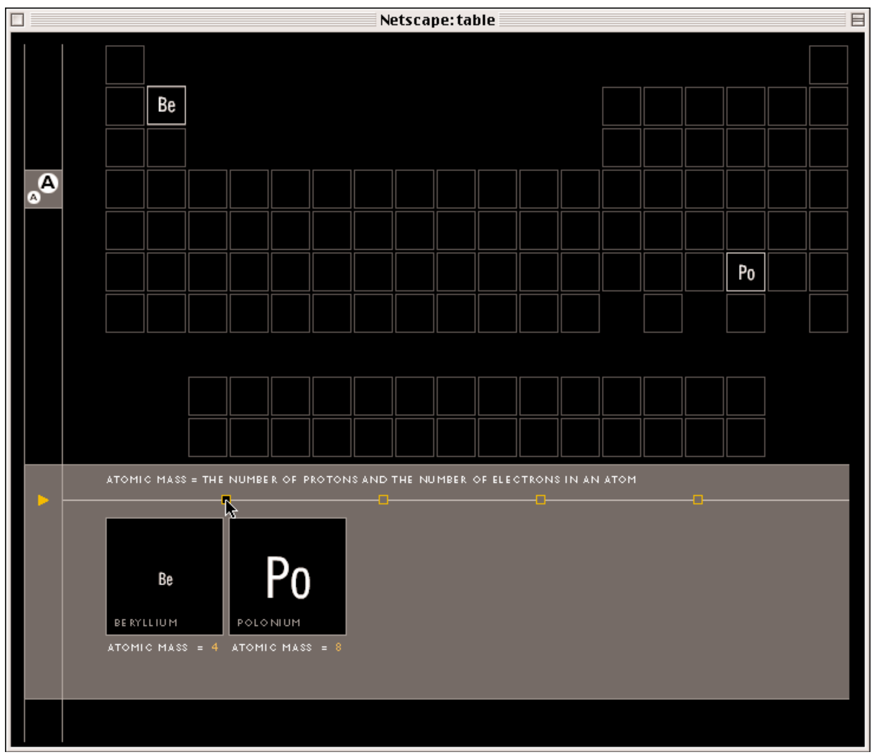


figure 25

Pacing and simultaneity can convey meaning themselves. Image sequences that are repeated consistently over a period of time are identified cognitively as patterns. Controlling intervals in the duration of each sequence can convey a progression. People also bring meaning to movement based on their previous knowledge of similar experiences.

> *"There is a visual literacy to timing, editing, and motion that we learn through experience. By the time we're young adults, we often take for granted the visual cues employed to tell a story—often used to tell it more efficiently. Just as we take for granted the act of talking to another person through a plastic impersonal device like the telephone (something that babies must learn); so too, do we take for granted the visual devices we've become accustomed to in the telling of stories on screen, such as close-ups, jump-cuts, establishing shots, and speed lines."*
>
> (SHEDROFF, P.290)

Quite different from all of my other studies in its departure from an analytical perspective, the biology/machine study *(project 6)*, an autonomous movie, allowed me to explore and analyze the use of pacing and simultaneity to convey the meaning of scientific concepts. The study attempts to draw connections in the transfer of energy between a mechanical object (a wind-up toy) and a plant. The correlating factor is energy intake and use. Since energy is one of the most difficult concepts for people to grasp, I found the challenge of conveying this abstraction concretely, by using time and imagery, to be difficult. Pacing is critically important in this project because it must describe energy by mimicking the behavior of energy. For example, the speed of the toy decreases as the amount of stored energy is depleted *(figure 26)*. The representation also needs to supply pertinent information to viewers,

figure 26

figure 27

enabling them to define relationships between the two objects. Timecode, a set of moving numbers that signify time, represents the differences in the duration each object needs to store and use energy *(figure 27)*. Both studies illustrated the importance of pacing and the potential it holds for communicating complex, abstract concepts. For example, pacing may be useful in explaining temporal scientific concepts that are difficult to visualize, such as the speed at which sound travels.

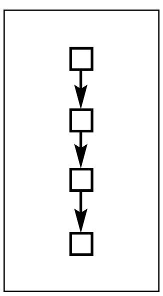


figure 28

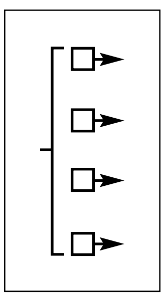


figure 29

Narrative and Indexical Structures

In conducting my studies, I've found that complex, abstract information can be communicated effectively in the form of narrative or indexical structures. A narrative *(figure 28)*, defined as a spoken or written account of connected events in the order of their happening, can be presented linearly—in a straight line, or non-linearly—out of sequence. In contrast, an index *(figure 29)* typically refers to a list of facts organized arbitrarly. In both cases, it is important for designers to consider how appropriately a particular structure matches their intended goals for the project.

In his book, *Image of a City*, Kevin Lynch describes urban environments and, through his collection of people's perceptions of pattern, creates a language of form. The language includes nodes, districts, edges, paths and landmarks. Each component has specific characteristics that distinguishes it from another and is used to explain the perceptions of city organization. Although his definitions are useful, for my purposes, the most interesting area of Lynch's work is his ability to view pattern finding from a user's perspective; a person's concept of relationships among units and a user's need to attain information at specific points in order to make confident decisions. Lynch argues that everyone forms cognitive maps—impressions of activity that are built in the mind—in order to move confidently through spaces.

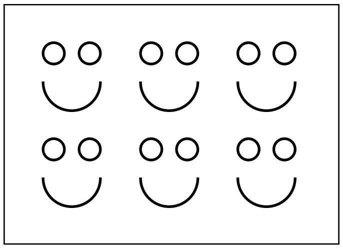


figure 30

People see patterns in the language of any form, such as faces *(figure 30)*. Therefore, Lynch's concepts can also be applied to the structure and presentation of information in digital environments. Learning and using his concepts in my own work has forced me to consider users during all stages of research and implementation, adapting structures that are appropriate to specific problems.

In his book, *Acts of Meaning*, Jerome Bruner discusses the patterns people find in form from a slightly different perspective. He explains that people make sense of extraordinary events by integrating them into stories (narrative pattern) that involve familiar contexts. Complex information, which is often difficult to visualize may also become easier to understand by communicating content narratively (BRUNER, P.47).

The sheer volume of information and inherent cause/effect relationships in the explanation of global warming issues lead me to determine that a narrative form of communicating would effectively convey the information I needed to present *(project 5)*. Since the cause/effect patterns are essentially stories—this leads to that—I found it useful to present the content of the project in a similar manner. Upon entry, viewers see a single noun, 'the sun' and an arrow that branches off of it. When selecting the arrow, the verb, 'generates' appears, connecting back to the noun, 'energy' *(figure 31)*. Several arrows branch off of 'energy' that can be clicked to

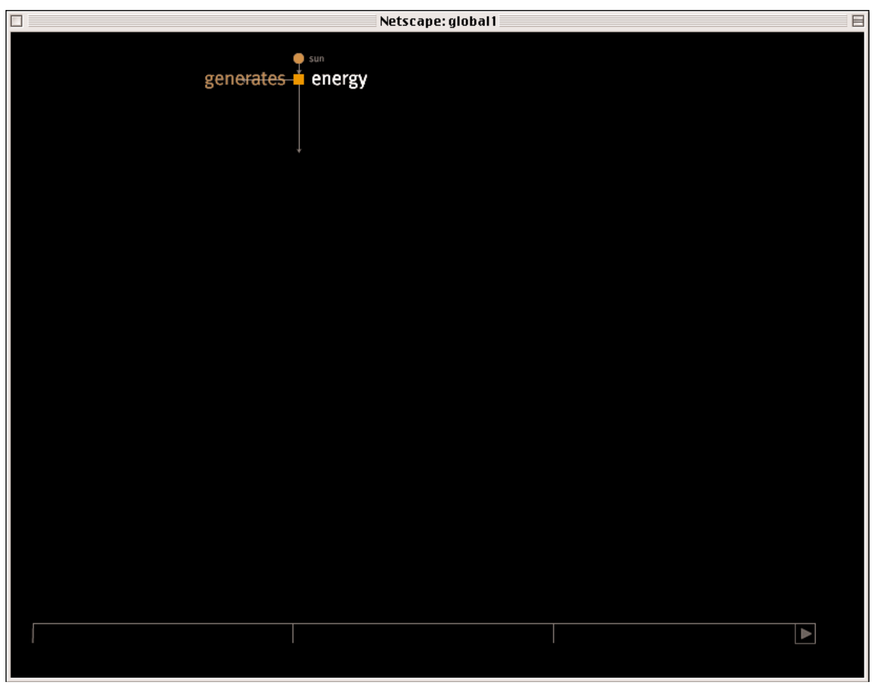


figure 31

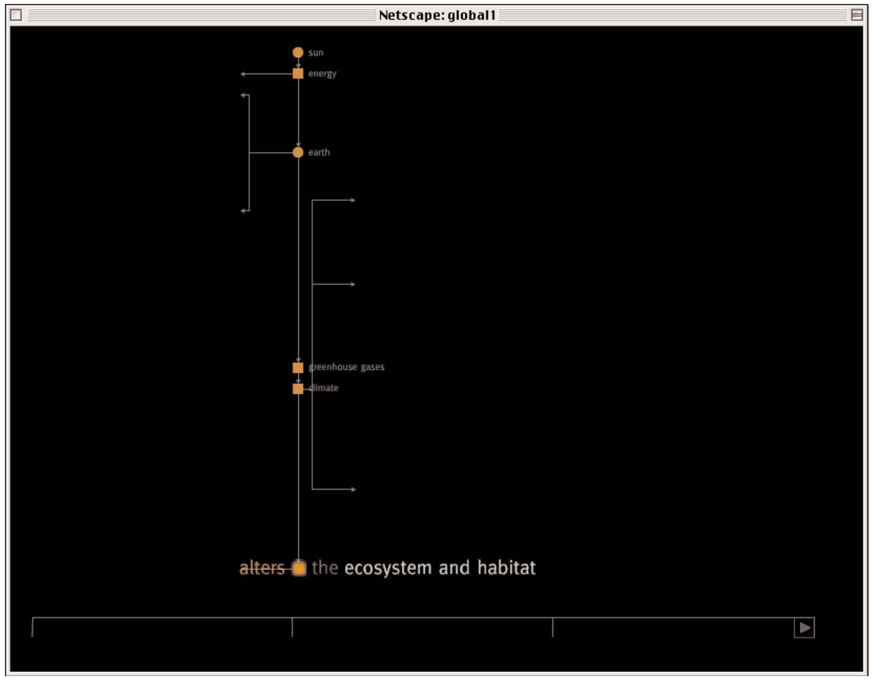


figure 32

reveal more verbs and corresponding nouns *(figure 32).* Interaction with the digital environment produces a visual, qualitative narrative, built over a period of time. This process is defined as concept mapping by education professors Novak and Gowin in their book *Learning How to Learn*. In building the information over time, I was also able to reduce the amount of overload placed on viewers.

In contrast, the complex structure of the periodic table *(project 1)* is based on a list of characteristics—reactivity for example. Elements can be identified by the various numerical values that describe their reactivity levels. By viewing the table's data simultaneously, relative to a single characteristic, viewers see patterns and can make comparisons. Unfortunately, it is difficult to isolate and examine specific characteristics when viewing all aspects of the periodic table simultaneously and non-hierarchically in a static form. However, by translating the content into a interactive digital environment, viewers are able to activate individual characteristics from a list of options which emphasizes its indexical structure. The physical space enables them to layer categorical content and view more than one pattern at a time *(figure 33).*

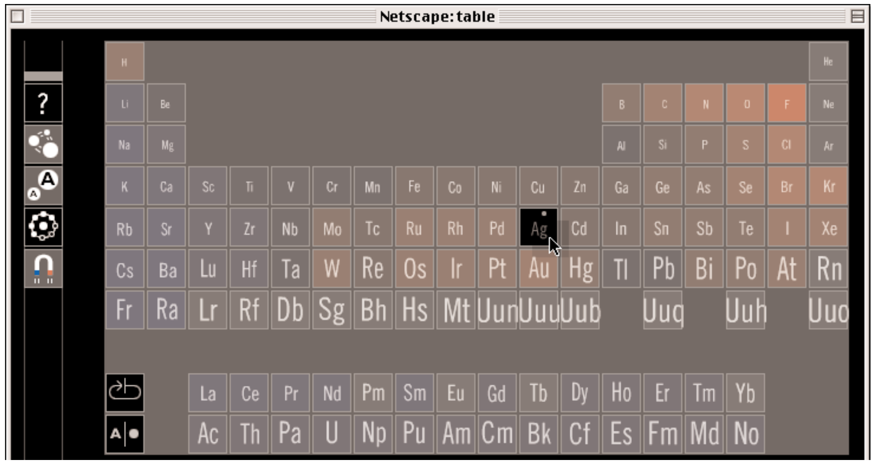


figure 33

Expectations and Perception

Just as the structure of information affects the manner in which it is received, viewers' perceptions of information systems influence the way they navigate through digital spaces. For example, the presentation of information may encourage viewers to search data, leading them directly to specific content, while others may prompt viewers to browse, building connections across information over time. Both methods can be effective means of communicating ideas. However, designers must be aware of both approaches, consciously implementing features that are appropriate to the task at hand. It is important to consider the expectations and previous experiences of users in determining the best way to present information.

In his book, *A Pattern Language*, Christopher Alexander discusses the fit between architectural form and people's expectations of events and interactions with their surroundings. He explains that buildings and the design of places should reflect the repetitive events among people. For example, to accommodate people's need for quick and easy entry into a building, eliminating the search for a door, designers must make an entrance visible as soon as a building is in sight. Alexander explains that people search for consistencies and disruptions in patterns. Raising the roofline around the entrance and allowing it to project beyond the contour of the rest of the building enables people to naturally notice the difference and move towards it. Main entrance characteristics that are consistently used from building to building form a recognizable pattern. Encouraging pattern discovery through repetition in the design of architectural spaces enables people to utilize their tendency to search for patterns, making the understanding and navigation of areas natural.

Alexander explains that people learn to read environments based on the repetitive elements that use similar structures, such as church steeples. Once interacting with these environments, associations are built between their appearance and the activities conducted there. Hence, similar looking structures will cause people to recall or orient behavior to familiar events or activities. Therefore, prior to constructing a building, it is important to consider its intended function and whether or not its structure will match people's associations with appropriate activity.

The same concepts apply to the design of digital spaces. For example, upon entering the periodic table study *(project 1)*, viewers see several blinking squares, which adhere to their notions of activity *(figure 34)* because a pattern of expected behavior has already been established by previous encounters with interactive media. Based on their experience with television, people expect motion to connote some form of activity whereas they anticipate a set of like objects that matches their notion of a web-based browsing mechanism to function in a predictable manner. The motion prompts people to roll the mouse over each area to receive additional information. In performing the action, viewers discover that each square serves as an entry point into the body of information. The system structure appears familiar to viewers, enabling them to move through the space in a natural way.

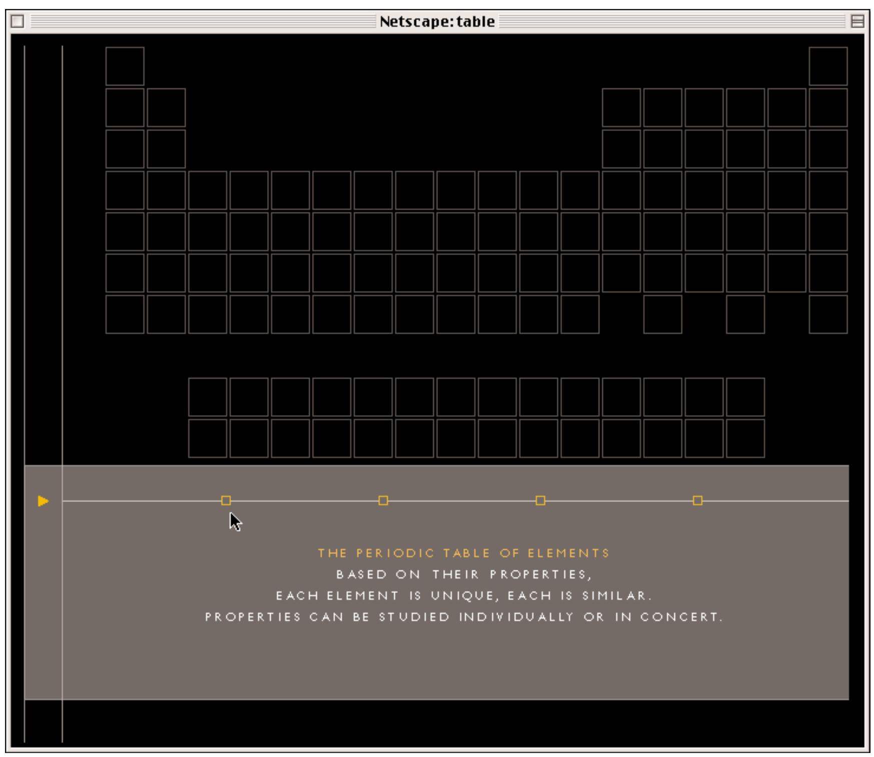


figure 34

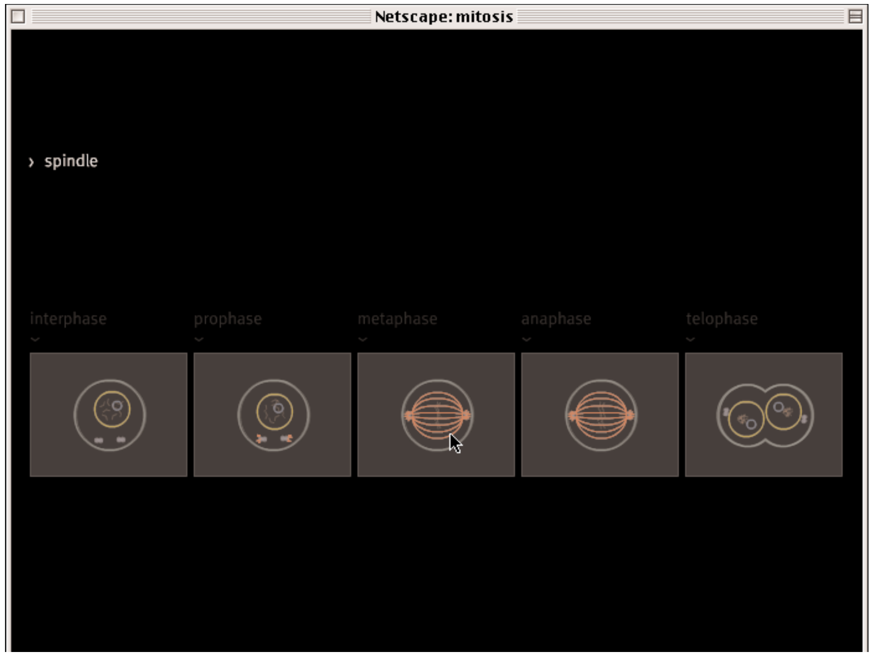


figure 35

The cell division study *(project 4)* functions similarly. After moving through a narrative structure in the forefront of the project that describes the nature and components of cells, viewers enter an area structured to encourage them to browse and explore the interface. People discover information by rolling over cell parts and the defined steps of the division process *(figure 35)*. The stages of cell division are fixed and can't be altered. However, the path viewers take in discovering and moving through the information sequence is not predetermined.

In contrast, the biology/machine study *(project 6)* presents information in a manner that does not encourage people to search, browse, or interact with information. Functioning as a narrative, content is presented incrementally following a specified path. Since information is in continuous motion throughout the duration of the study the representation doesn't invite viewer participation but accurately depicts its use.

The various representation methods used in each of these studies have shown me the value in fully understanding project goals—both for designers and viewers. It has also revealed ways of making the acquisition of information more intuitive. By integrating characteristics of actions performed in everyday life, people can easily understand the ways in which they are able to move through digital spaces.

In his book, *Experience Design 1*, digital designer Nathan Shedroff explains that "In a broad sense, interaction encompasses everything that people do, any action they perform. On a philosophical level, interaction is a process of continual action and reaction between two parties (whether living or machine)." (SHEDROFF, P.142) With regard to a digital environment, interactive systems require some form of audience participation.

> *"Many real-space experiences (such as parties and other events versus art displays or theater) require participation in order to be successful. These are often the most satisfying experiences for us."* (IBID., P.148)

Using human interaction as a reference point, designers have the tools to create digital interactions that mimic nature. More importantly, constructed interactions need not be restricted to entertainment devices; they can also be used for the acquisition of complex, abstract information. In fact, applying meaningful, customizable interaction to this type of content accommodates multiple learner types, enabling them to access information at their own pace and in a manner they prefer.

The previous section explained the importance of understanding people's expectations in navigating through digital spaces. Although they may not realize it, viewers also have expectations for the types of interactions that they encounter. Designers must recognize and understand the desired interactions in order to create digital environments that produce the sensory output their audiences need and desire.

> *"...studies tell us that we are more likely to notice, encode and subsequently remember information that is consistent with our initial expectations."* (AUGOUSTINOS AND WALKER, P.44)

People's expectations are based on their previous experiences. In their book, *Wet Mind,* neuro-scientists Kosslyn and Koenig state "The fact that we can identify objects visually and can visualize objects in their absence implies that we store visual information." (KOSSLYN AND KOENIG, P.79) People recall stored memories when they view something that is a close match and are able to perceive content that is similar to their stored memories faster than information that is new and different. Designers can make use of this capability. This process may help designers determine and implement interaction representations that will be understood by the majority of their audience. It may also help them discover points where alternate ways of accessing information are necessary to allow people to make content connections that are logical to them.

Customization

> *"Customization is one form of adaptivity that allows people to overtly choose options to tailor an experience to their needs and desires."* (SHEDROFF, P.184)

A customizable interface enables viewers to move through information as they choose: what they see, when they see it, how long they view it, the path they will take, etc. Therefore, customization has a direct bearing on educational interfaces. Highly malleable environments can accommodate multiple learner types by enabling them to tailor their experiences to their individual preferences.

> *"It is possible for experiences to adapt to participants in a variety of ways. The experience can change based on the behavior of the user, reader, participant, actor, or to a user's interests, needs, goals or desires (stated or inferred from behavior), experience or skill level, or even to the time of day or year, or even location (of experience or participant). It's important for designers to understand which attributes will make an experience more successful and valuable to users (which attributes are most appropriate), and balance these with those that are possible to create with the system, resources, budget, or schedule."* (IBID.)

Several of the studies I have created include some form of interaction, most of which is customizable in some manner. The global warming study *(project 5)* enables viewers to determine their own path through the supplied content at their desired pace. It also allows them to turn visual feedback off and on as they chose *(figure 36).* Similarly, the periodic table project *(project 1)* invites viewers to layer information, enabling them to decide how much they see throughout their exploration of the table *(figure 37).* In contrast, the animal locomotion study *(project 3)* allows people to determine the speed at which they view information. Since horses,

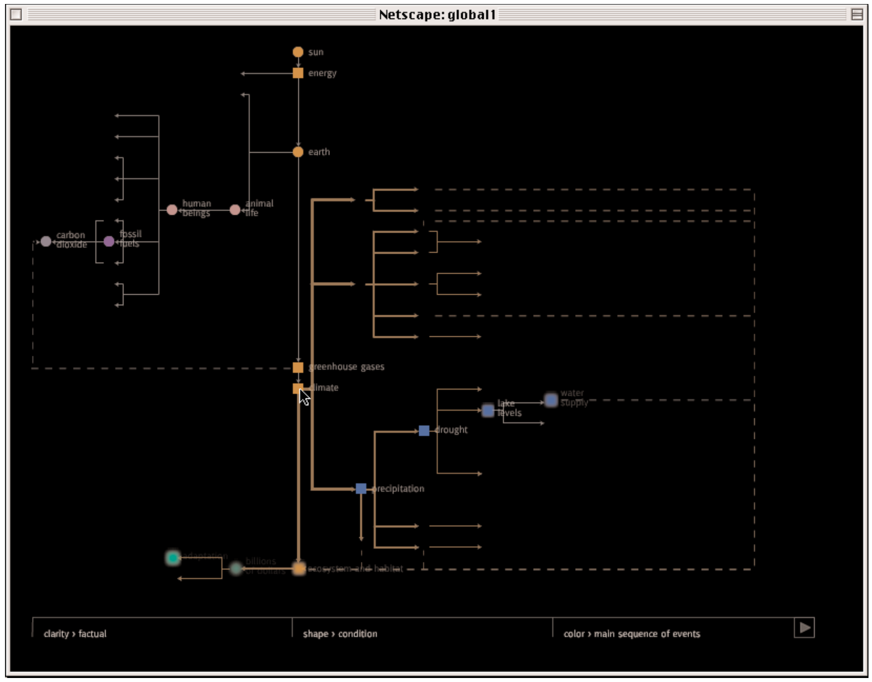


figure 36

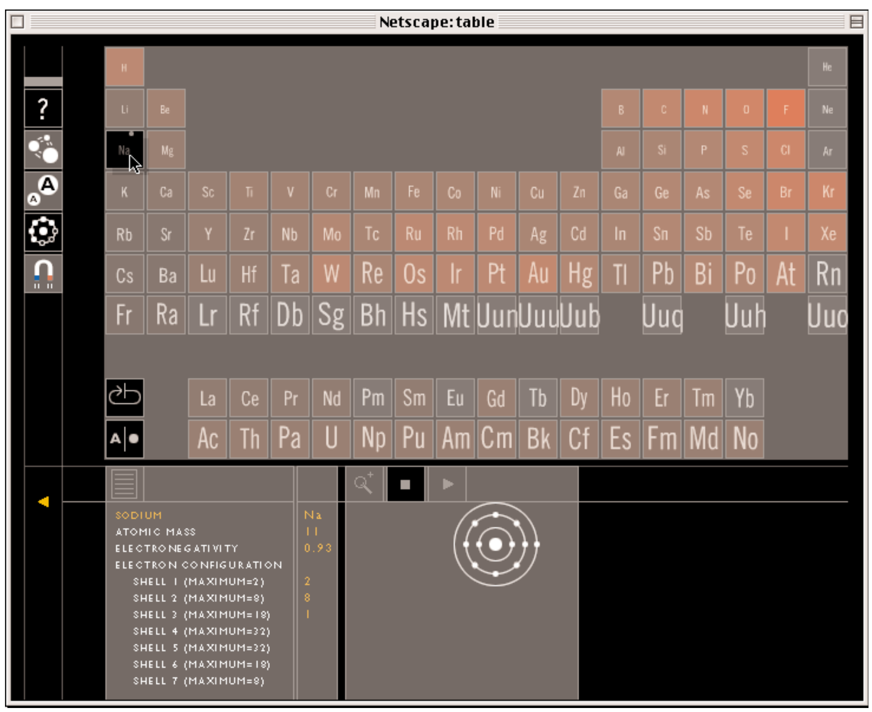


figure 37

figure 38

whose movements are quick, are the subject matter, it seems appropriate to provide this option *(figure 38)*. The cell division and helium inhalation projects explore additional customization features. In the cell division study *(project 4)*, viewers are able to scale cells in order to see their components more clearly, functioning similarly to a microscope *(figure 39)*. The helium inhalation project *(project 2)* connects the duration of time in which the mouse button is depressed to the amount of helium the performer inhales *(figure 40)*. Viewers are able to perform the actions as often and as frequently as they prefer, which brings about issues of defined duration.

I've discovered that even if a digital interface is presented as an autonomous movie, as in the biology/machine project *(project 6)*, it can still provide optional modes of interaction. Although I defined the duration of the video, viewers are able to stop the movie at any point and replay sections or the entire movie as often as they wish.

The range of customization features I have explored has exposed me to the growing array of possibilities provided by digital technology. Additional research will indicate the extent to which meaningful and appropriate interaction can enhance learning environments.

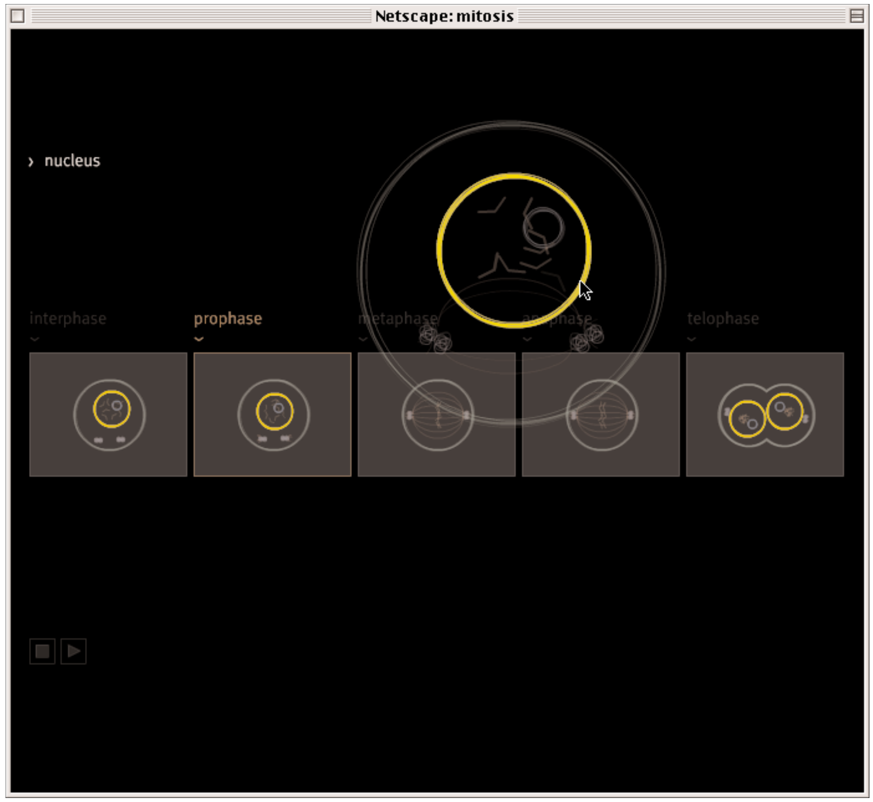


figure 39

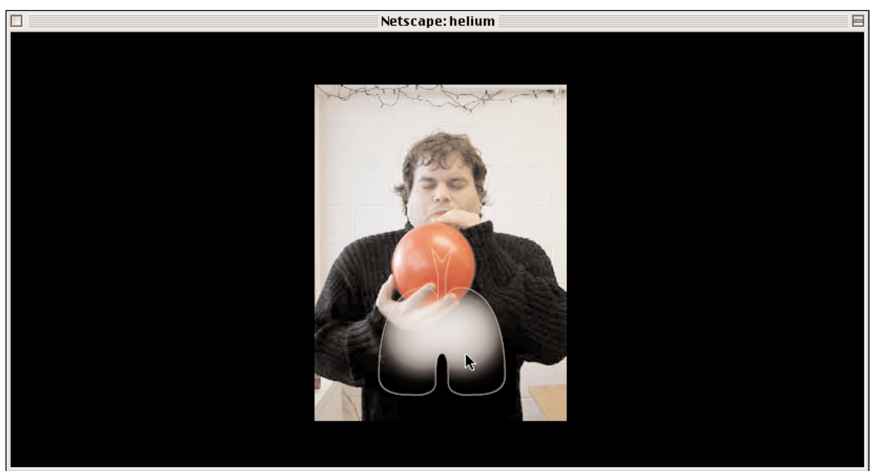


figure 40

PLACE SCHEMAS: *deals with spatial organization and responds to the laws of physics; people understand objects when their configuration responds to gravity, not when they are tumbled* (AUGOUSTINOS AND WALKER, P.36)

BODY SCHEMAS: *deals with the translation of physical experiences into visual forms; force, path, and diversion, for example, can be represented visually* (JOHNSON, P.44)

Mimicking Known Behaviors

People constantly store patterns of information to be utilized and edited as they encounter new situations. They are explained from a cognitive perspective by linguist/philosopher, Mark Johnson in his book, *The Body in the Mind*. He refers to these patterns interchangeably as schemas and gestalt structures. Johnson uses the terms to mean "an organized, unified whole within our experience and understanding that manifests a repeatable pattern or structure." (JOHNSON, P.44) Throughout the book he explains the components necessary for pattern recognition and how people comprehend and store schemas.

Each time people encounter unfamiliar situations they match the new events to stored schemas. Decisions based on familiar events are much easier for people to make quickly than those are that can't be compared to stored memories. It seems natural to integrate characteristics of known schemas into digital environments because they can improve response times by making interactions more intuitive. Connecting mouse interaction, through movement, responsiveness, etc., to human (known) behaviors, can also provide the illusion of familiar interaction. In essence, people can digitally and interactively experience how something feels, elaborating on the past experiences that inform the understanding of new information.

Augoustinos and Walker confirm this notion in their book, *Social Cognition*. They explain that enabling people to answer questions based on schemas helps them anticipate the types of interaction, making the situation more predictable and controllable. (AUGOUSTINOS AND WALKER, P.37)

> *"The best experts and most proficient communicators are always adapting their interactions on-the-fly to suit the reactions they perceive in their audiences from body language, statements, answers to questions, and so forth. Because we are accustomed to this kind of behavior from people, it is natural to expect systems to respond in kind."* (SHEDROFF, P.184)

I tested this concept in the helium inhalation study *(project 2)*. Upon entering the interface, viewers explore a screen filled with a sky image by moving the mouse. On one side, a vertically-elongated cloud that appears to move quickly upward based on the passing sky image *(figure 41)* replaces the cursor. On the other side, the cursor is replaced with a horizontally-elongated cloud that seems to move slowly downward, resulting from a different movement of the passing sky *(figure 42)*. The images give viewers the sensory illusion of weight—light helium versus heavy air—that concretely describes the properties of each gas in a familiar manner.

figure 41

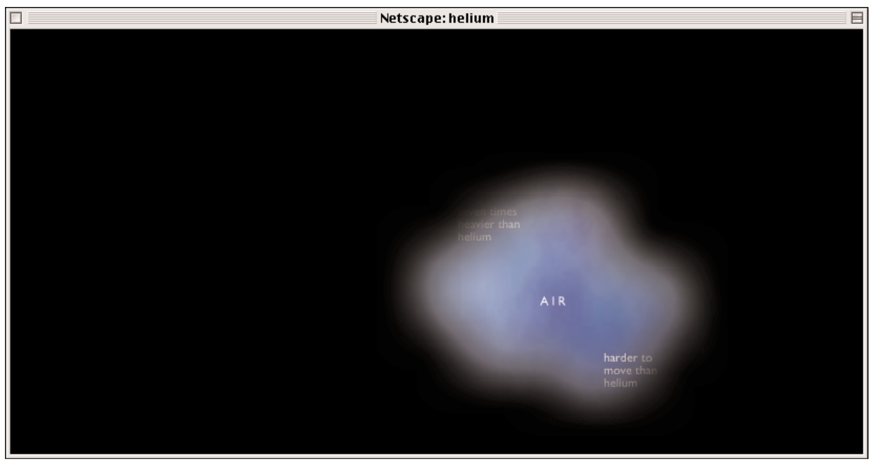


figure 42

Although some interfaces utilize schemas in the construction of digital interactions, few use them as extensively as entertainment devices, such as video games. The designers of game environments consciously attempt to make the act of digital play as real as possible, and therefore, mimic behavioral schemas. In contrast, complex educational information which is accessed digitally often includes interaction through a series of tools, signified by icons and housed in a rectangular bar; such interaction doesn't resemble people's natural behavior.

Abstract representation of actions in an iconic form is often cumbersome and redundant. Based on my research, I believe interactions with complex, abstract information can be just as rich as the experiences provided by entertainment devices and as seamless in their initiation. Enabling people to interact directly with objects replicates concrete experiences and eliminates the distracting awareness of mediating tools. People are enthralled in the experience because their focus isn't directed towards learning the function of tools. Instead they interact with the digital environment the way they do with the natural environment, which often doesn't require as much thought, reflection, and judgment.

By understanding schemas, designers gain insight into the assumptions of viewers and integrate their expectations for interactions into the objects themselves. For example, instead of using arrows to navigate forward and backward through a digital piece, moving the cursor to the right and left sides of the screens can perform the same action, reducing visual clutter and making the task intuitive.

> *"Thus schemas also influence processing time, with the research literature predominantly indicating faster processing times for schema-relevant as opposed to schema-irrelevant information. People take less time to process, interpret and remember information which is consistent with their general expectations."* (AUGOUSTINOS AND WALKER, P.45)

The cell division project *(project 4)* enabled me to explore the idea of necessary tools. In the first study, I provided a tool bar that viewers use to move through the representation and that highlights and scales objects *(figure 43)*. Unfortunately, the tools aren't very engaging, causing viewers to feel removed from the experience, the icons also take up valuable screen space. In a second attempt at improving interactive tools, I allow people to highlight components of the cells by rolling over the pieces, to stop and start movement by clicking objects, and to use screen space as a scaling device *(figure 44)*. This study successfully encourages concrete interaction with objects rather than with tools and appears more visually inviting to viewers; the interface is a more natural and seamless part of the experience and doesn't constantly remind viewers that they are using a computer.

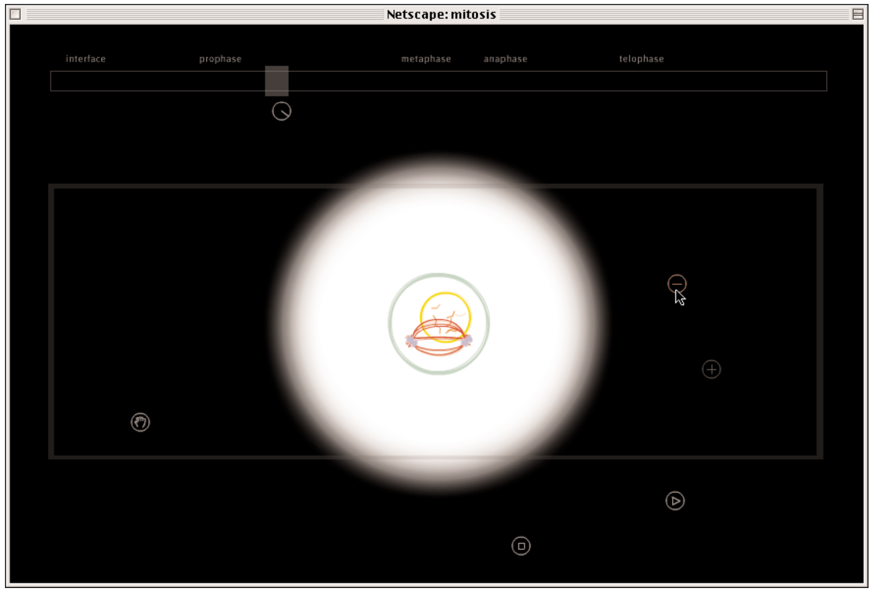


figure 43

figure 44

In his book, *Art as Experience*, philosopher John Dewey states that "every experience is the result of interaction between a live creature and some aspect of the world in which he lives." (DEWEY, P.44) He describes experiences as having a similar pattern and structure although their content may be quite different. Experiences consist of actions and consequences in which people join together in the act of perceiving; experiences have a beginning and a sense of closure. An understanding of experience structure and how people perceive it may help designers more effectively evaluate the representations they construct.

Analyzing experiences from a design perspective, Nathan Shedroff explains that "Experiences are the foundation for all life events and form the core of what interactive media have to offer." (SHEDROFF, P.4) The success of digital experiences is dependent on the representation of information. Thus, designers must consider carefully the experiences they hope to create and choose wisely the methods that effectively accomplish their goals.

Unfortunately, as previously stated, the design of information to be accessed in an interactive digital environment often replicates textbooks, not experiences, in its form and content. Research has shown however, that by providing experiences that are exploratory, sensory, and enjoyable, students increase their critical thinking skills.

> *"...outside of art and design education, few educators are aware that thinking can occur in other than verbal and mathematical modes. Yet sensory modes of thought, especially the visual mode, are at the very heart of thinking."* (MCKIM, P.29)

Designers must understand the need for interactive digital experiences to build on behaviors people recognize in their look, feel, and sound. A better understanding of natural experiences enables designers to create more rewarding digital experiences.

"Most technological experiences—including digital and especially, online experiences—have paled in comparison to real-world experiences and have been relatively unsuccessful as a result. What these solutions require first and foremost is an understanding by their developers of what makes a good experience; then to translate these principles, as well as possible, into the desired media without the technology dictating the form of the experience." (SHEDROFF, P.3)

Previous technology didn't provide the tools designers needed to make experientially rich, digital environments. However, designers now have the ability to create interactive digital experiences that encourage viewers to feel, explore, and critically analyze information they encounter by building onto their existing knowledge of experiences. Designers must not allow previous technological restrictions and educational devices to dictate their solutions. Instead, now more than ever, they need to look at design holistically, incorporating activities of their environments and infusing those experiences into their work.

"Experiences that seem to adapt to our interests and behaviors (whether real or merely simulated) always feel more sophisticated and personal. Though these experiences, necessarily, take more energy and planning and are significantly more difficult to accomplish, they are more valuable to the participants." (IBID., P.184)

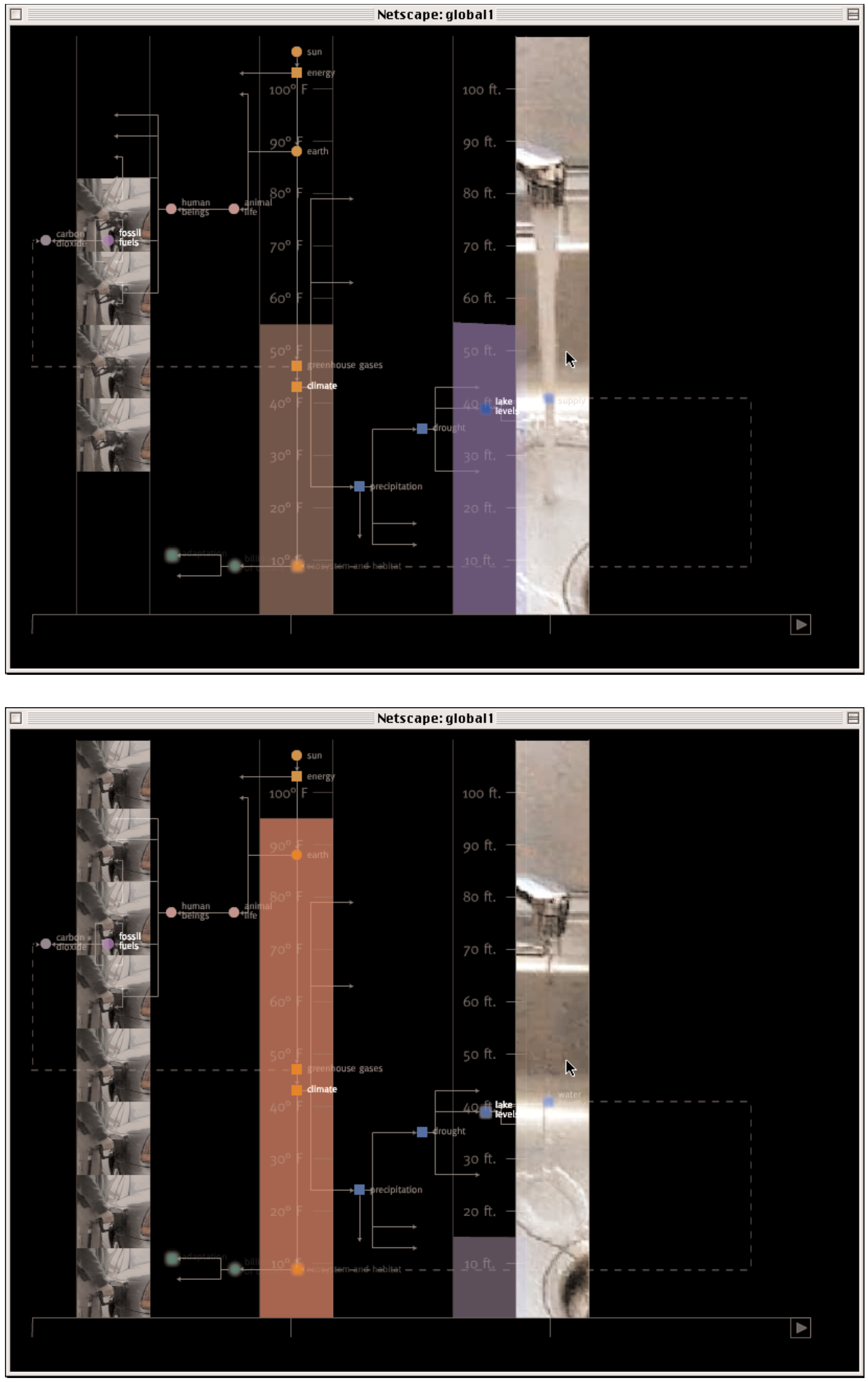
Recall and Engagement

As in creating effective interactions, schemas are also an integral part of constructing engaging experiences. Movement, imagery, sound, texture, etc. trigger the recall of familiar information. Integrating known behaviors into the digital representation of experiences enables a quick and easy interpretation by eliminating the need for big conceptual leaps. Digital environments that look, feel, and sound familiar also build emotional connections to content, which make interactions with information more fulfilling for viewers and more likely to be remembered. For example, people who see a rigid, illustrated icon of a pillow are less likely to consider its softness, material and environment. However, those who view soft-focus images of feathers juxtaposed with an image of a pillow that is softly lit in an environment of quiet sounds are more likely to make rich associations. Therefore, experiences that are often conveyed abstractly in digital environments can also be delivered in a concrete, sensory manner.

Dewey explains that an important part of experiences is the continuous melding of parts. Although people can recall specific points of an experience, signifying that each component has its own identity, the parts often blend together, creating a unified whole. He attributes this melding to the immersive quality of engaging experiences. People become enthralled in activities, especially those that function like narratives, which are based on specific segments. Stories include a point of inception, a stage of development, and a climax of fulfillment. Once people buy into an experience, they become enthralled by the activity and in their peripheral vision distracting elements disappear. Dewey explains that once people are engaged in an experience they participate in a process of intaking and outgiving; they receive information and react to it. Designers often refer to this as a push/pull activity, which can be created in the representation of information.

Several of the studies I made attempt to construct experiences that engage and fulfill viewers by using some of the aforementioned concepts. The helium inhalation study *(project 2)* integrates the sounds and expressions of people engaged in the comical experience into the digital interface *(figure 45)*. The global warming study *(project 5)* functions similarly by using repetitious sounds and images of a person pumping gas and water streaming from a kitchen faucet to build connections between everyday activities and global warming causes and effects. As the number of people pumping gas increases, the amount of water flowing from the faucet decreases *(figure 46)*.

figure 45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lake levels
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70 ft.
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50 ft.
30 ft.
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10 ft.

figure 46

figure 47

figure 48

In contrast, the biology/machine study *(project 6)* focuses on conveying energy consumption and use by matching people's perceptions of energy, both visually and through movement and pacing. Because it is a autonomous movie, the creation of an engaging experience and the understanding of content are heavily dependent on cinematography rather than interaction. The representation of information enables people to sense the intake, build-up, and use of energy and the cinematic structure matches the beginning/middle/end expectations of an experience. The difficulty lies in the analogy of plants to machines. Since both use energy for slightly different purposes—one to grow *(figure 47)* the other to move *(figure 48)*—the interpretation of the activity needs to differ as well. A careful analysis of their similarities and differences was necessary to accurately represent the connections between the objects.

The studies showed me the importance of conveying information in an engaging, experiential manner that is enjoyable, exploratory, and resembles nature. Understanding the components of experiences has also helped me to evaluate the effectiveness of my work.

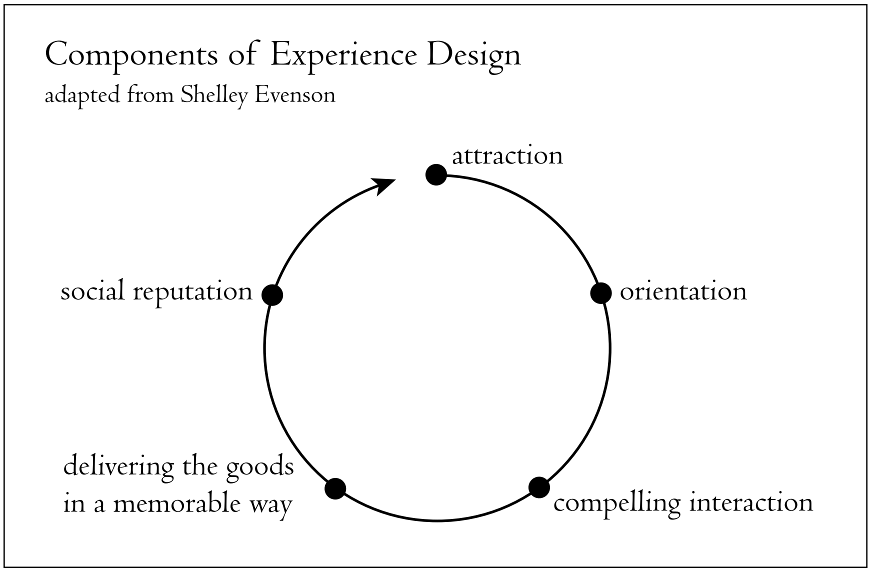

figure 49

Discovery and Critical Thinking

Experiences encourage viewers to discover information in ways that are enticing, and in turn draw viewers into the concepts. This is a push/pull mechanism. Shelley Evenson's diagram describes the components of an experience in detail *(figure 49).* In addition to the structural components an experience must include—attraction, engagement and conclusion (SHEDROFF, P.4)—she explains that successful experiences are defined by compelling interactions.

Experiences that are visual, temporal, and aural are likely to be more compelling than those that use only one channel of information. Further, experiences that require viewers to discover information, rather than receive it passively, are also more engaging and encourage viewers to think in ways that are different from their typical processes. McKim supports this notion by explaining that "The discovery of information is at the heart of thinking. Thinking needs to be taught to enable students to move beyond their known patterns of thought." (MCKIM, P.28)

> *"The two most successful approaches to the education of thinking are the 'discovery method' and the 'strategy method.' In the discovery method, students are not required to memorize concepts but are stimulated to discover concepts for themselves; they learn to think independently because they are challenged to do so."* (IBID.)

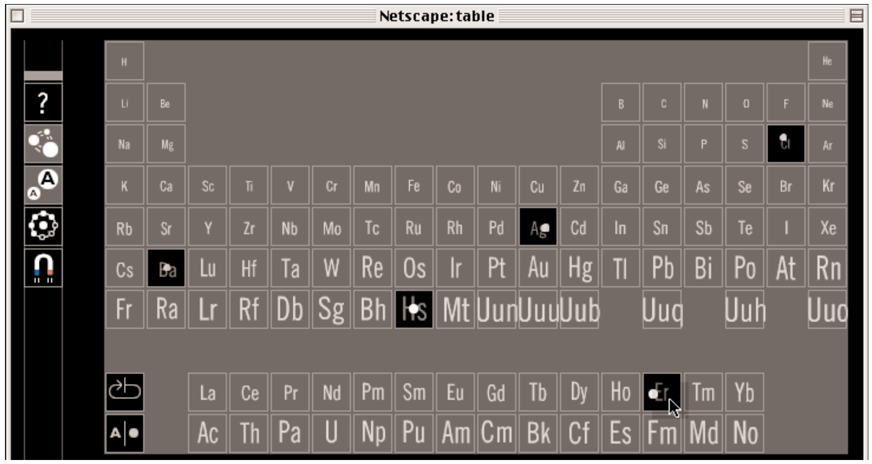

figure 50

Unfortunately, scientific representations often fail to create compelling experiences that utilize the push/pull process as a form of learning. Instead, they typically encourage passive reflection and memorization of facts, formulas, and statistics, emphasizing details over concepts. I believe designers have the ability to create learning environments that promote more compelling engagement and that these experiences can improve the thinking abilities of all students.

The periodic table study *(project 1)* integrates a push/pull learning approach with the representation of information. By providing a blank periodic table rather than quantitative data relating to each element, viewers are encouraged to explore the qualitative interface, compare their findings, and draw their own conclusions *(figure 50)*. For example, differences in sound pitch describe the number of electrons located in the outer shell of each element. Those that are less full are signified by a high pitch, while a low pitch implies the shell has more electrons. Although the sounds are descriptive, they also function as an audio keyboard. Viewers can compose their own playful music while comparing information about the elements. The exploratory and playful nature of the project defines the learning experience.

This study, as well as others, enables students to build and make comparisons among concepts because content is reduced to perceivable patterns. It is important to note that the experiences I constructed do not provide all the answers. Instead, they intentionally eliminate some information so students are forced to think critically about what they discover and encounter.

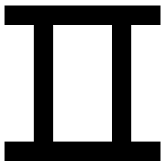
figure 51

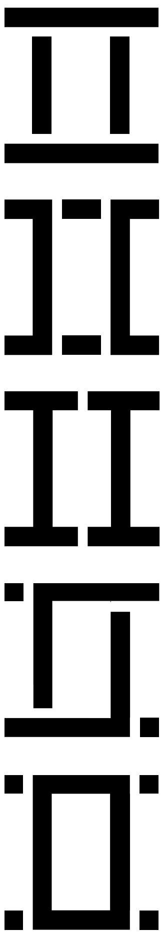
figure 52

Design methodologist, Edward DeBono describes the different modes of thinking that these experiences cultivate in his book, *New Think*. In it, he explains that people can think vertically, latching onto their first idea and refining it incrementally, or think laterally, by exploring multiple scenarios (MCKIM, P.65). Experiences that leave questions unanswered and are based on patterns encourage lateral thinking.

DeBono's diagram *(figure 51)* illustrates this point. In it, he asks viewers to clearly describe the shape in the least number of words possible. The key to solving the problem effectively is to explore multiple ways of repatterning the shape prior to selecting the easiest one to verbally describe *(figure 52)*. This is a practice of vertical thinking that is encouraged by patterns. (MCKIM, P.65) McKim defines this process as projection. He explains that as we are faced with an ambiguous pattern, "we tend to rummage about our imagination until we find a meaningful image that we can project onto that pattern." (MCKIM, P.64)

The studies I created have shown me the value of creating digital learning environments that encourage exploration and critical thinking. Although connections may seem less obvious in some studies, the devices viewers need to make their own connections are evident.

The six studies I created as part of my final project explore the visual, temporal, and aural characteristics of concrete, sensory experiences as ways of communicating complex information in a simple, intuitive manner. My analysis of diverse scientific data and concepts revealed similar results—typical quantitative abstract representations do not always convey pertinent information nor do they engage viewers' interest in learning experiences. Through research and making, I found ways of utilizing digital media to combat the communicative deficiencies of current learning materials. My discoveries enabled me to document similarities among the studies, which I hope will prove applicable to other forms of content.

Although further research needs to be conducted to determine the extent to which qualitative/concrete representations of information in digital media can benefit and enhance learning, The ideas I am proposing function as a seed for additional study. My determination is that all learners can gain a better understanding of overarching concepts, rather than an inventory of details, through qualitative representations of information patterns; that learning can be fun and engaging through environments that are experiential and sensory-based, appropriately mimicking nature in their appearance and/or function. I also demonstrated the value of interaction and exploration as significant outcomes of the project. Although all of the studies provide accurate information about scientific concepts, I don't think any of them function effectively as stand-alone learning devices because details are often missing. However, I believe the strategies I have constructed serve as starting points for research that explores the combination of quantitative and qualitative information and may eliminate the need for supportive teaching materials.

By basing my studies on scientific data that is diverse in content and representational form, I discovered ways of communicating information visually, temporally, and aurally that are not dependent on specific content. Thus, the representations are valuable strategies for communicating concepts in disciplines other than science. I believe a next step of research may include examining the results of applying these strategies to other areas of science, as well as mathematics and the language arts. Since the means of communication I propose are not based on a textual language, universal forms of education may also arise. Further investigation by a team of researchers with expertise in a range of relevant disciplines will provide valuable new results beyond those of this short study.

The strategies may also affect the nature of current learning environments. Since the studies I created exist digitally and are small in size, they can be delivered easily via the internet. Therefore, graphic representations that are also sensory-based may be simple and efficient ways of communicating complex, abstract concepts to people learning remotely. For example, digital representations of information may function as supplemental teaching components for lectures.

My next step will be to test the studies I made. I plan to observe students' interaction with the learning environments, documenting my findings. I also hope to receive feedback from students, as well as educators. I anticipate distributing a written questionnaire, eliciting answers to specific questions. The survey would include an area for writing comments. I believe input will help me define issues I may not have addressed and need to consider. I think it will also indicate the effectiveness of the ideas I am proposing.

I have documented my process throughout the research and creation stages of the project and have charted my discoveries, which are shown in the appendix of this document. Illustrated are my areas of focus and those that need further exploration, which time didn't permit. There are two areas I specifically need to address; time and how it can be represented and sensed, and sound as a means of providing information not present in visual and temporal representations.

I believe my documentation clearly identifies new directions for further research. I plan to continue studying the use and affects of schemas in digital representations of information. I anticipate continuing my study of patterns and their educational benefits, extending beyond single-person viewing to include collaboration. I believe patterns not only help learners decode important information, but lead to the encoding of larger, connected concepts through making. I believe this project has laid the groundwork for significant research, which I hope will yield substantial educational results.

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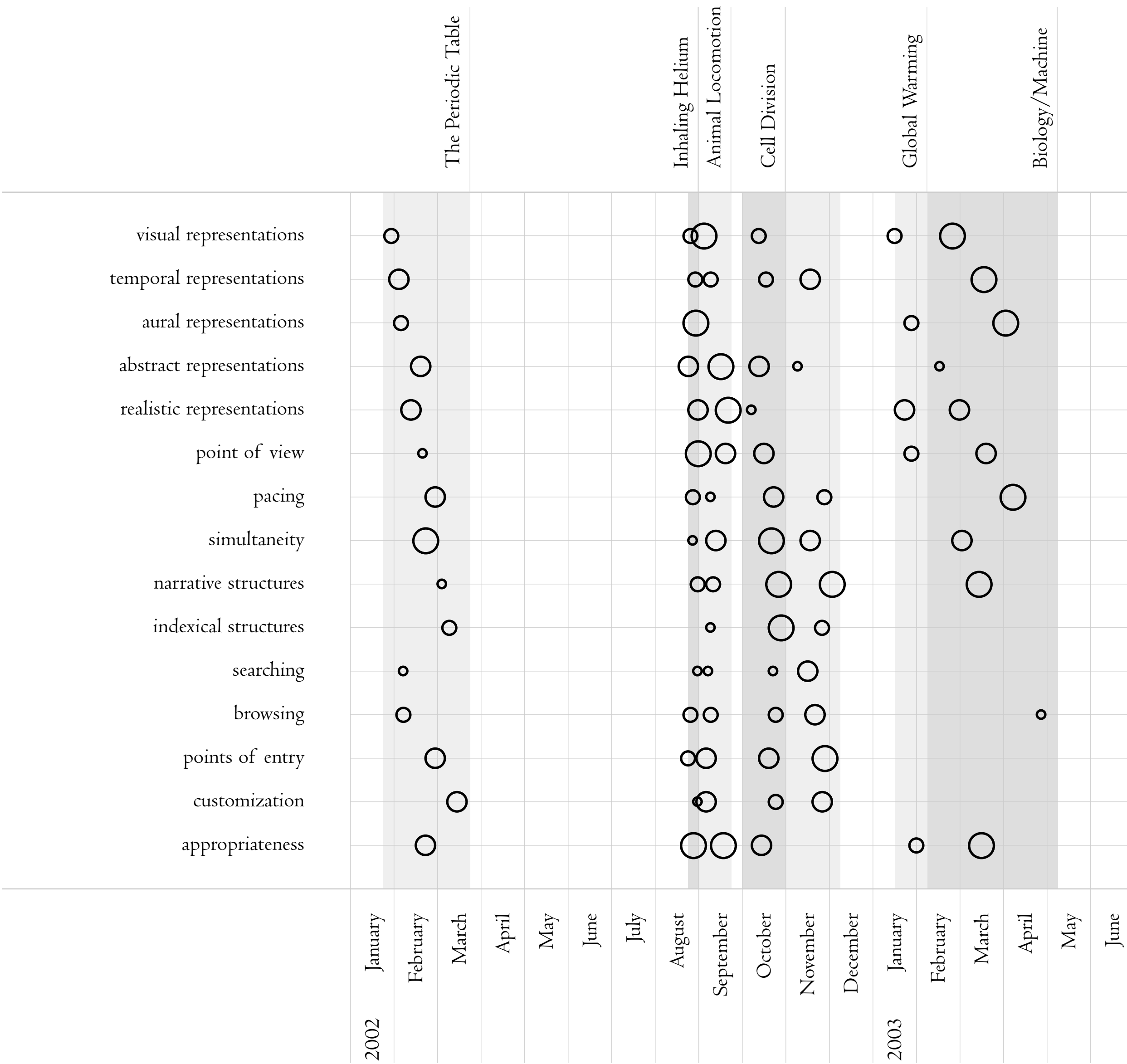
APPENDIX

The first three pages of the appendix illustrate my areas of focus and the distribution of time for each project in relation to others. The diagrams list the design- and education-based issues I tackled and the design approaches I employed. Categories are derived from an analysis of my studies and process. Wanting to embrace the exploratory nature of the project by allowing each study to help me define the next, I purposefully didn't attempt to create a preliminary plan for moving through my work. I believe making such a list would have dictated the focus of each project, closing off alternative avenues that naturally arise, and indicated that I knew all the answers before getting started, which I certainly did not. However, early in my process I did search for a set of scientific concepts that presented a broad range of formal and content opportunities. Although the topics of my studies differ significantly, my diagrams reveal the similarities and differences in my process. They also indicate holes in my research (which I may want to address in future studies) and ongoing areas of interest.

The remainder of the appendix explains the origin, motivation, context, and process related to each project. Each description is followed by images of key frames and captions corresponding to the relative interface. Although the printed documentation provides substantial information about each study, the CD in the back of this better represents the content by enabling viewers to engage in the sensory acquisition of scientific information.



The Periodic Table
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Animal Locomotion
Cell Division
Global Warming
Biology/Machine
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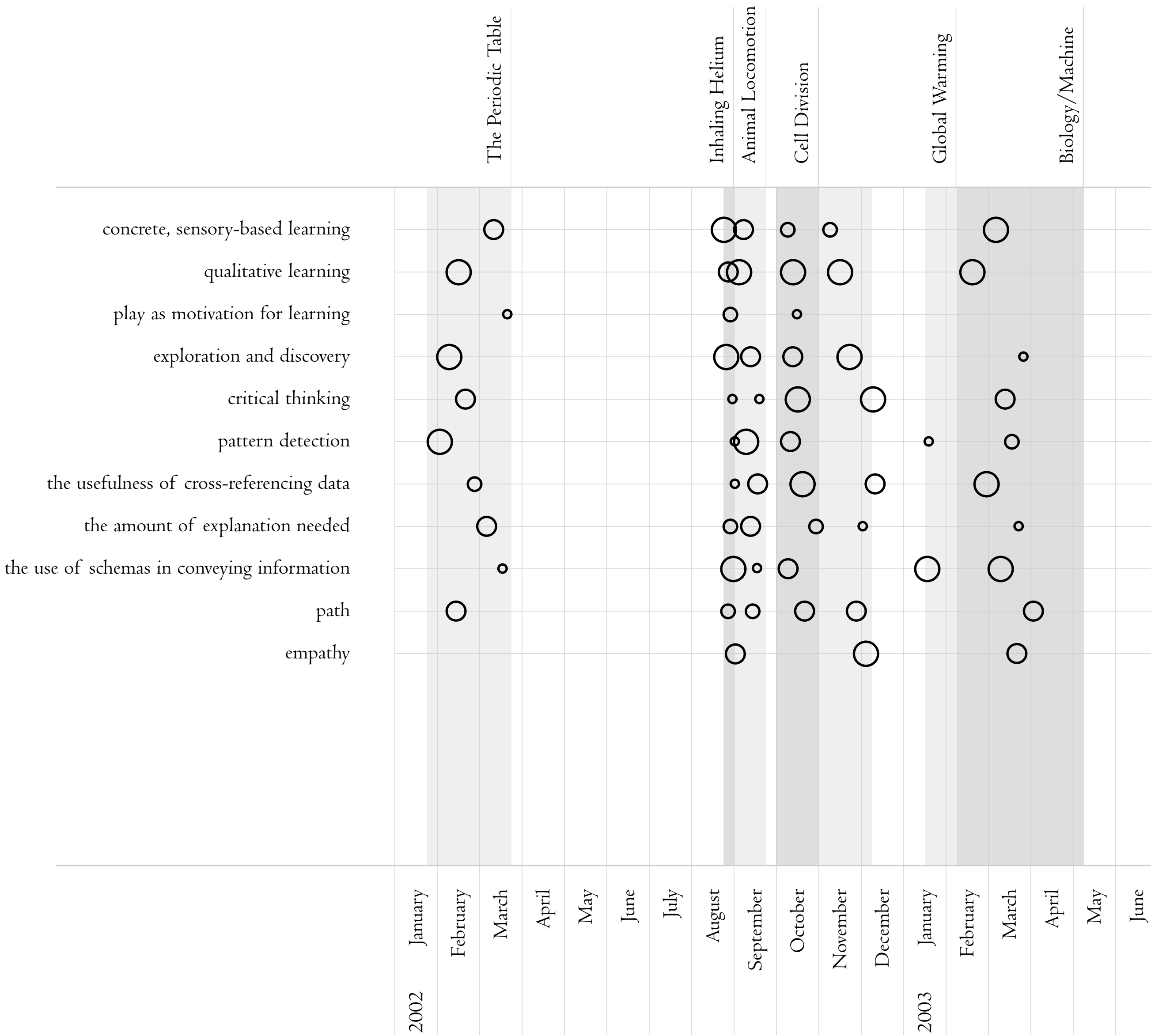
The Periodic Table
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Cell Division
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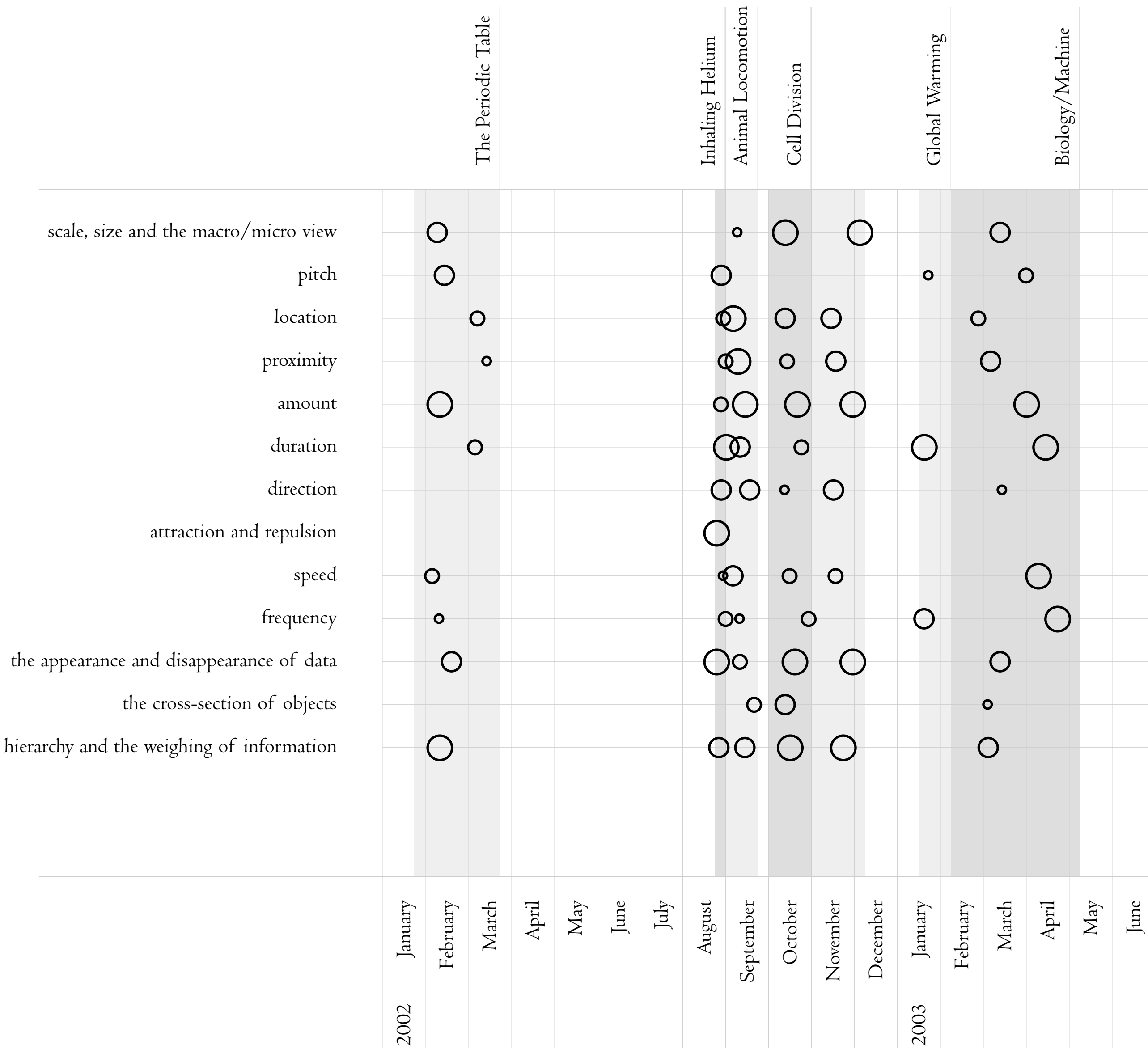
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Cell Division
Global Warming
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PROJECT 1 | THE PERIODIC TABLE OF ELEMENTS

How can sound, motion, and shape be used to communicate complex information?

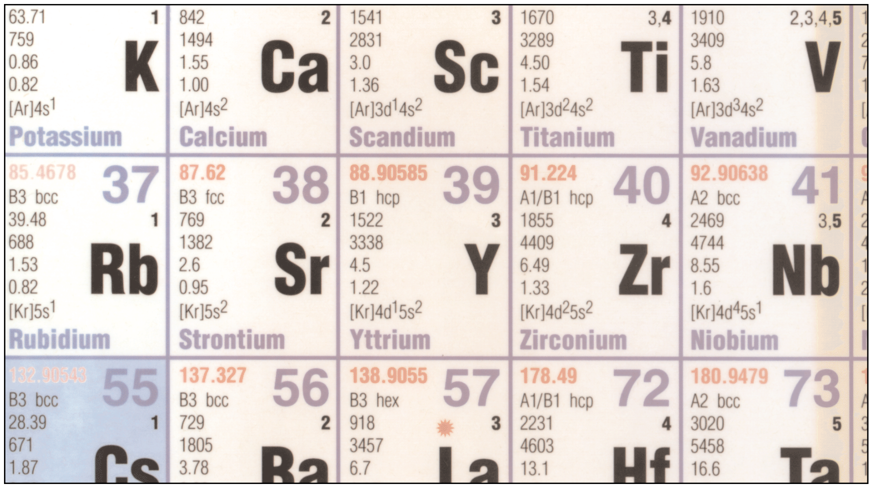
PROJECT DESCRIPTION

The printed version of the periodic table of elements, developed by Mendelev, and used in most chemistry classrooms, contains a vast amount of data packed into a compact systematic grid. Written definitions describing the table's structure and content usually accompany it. Unfortunately, the necessary definitions are often abstract, data is quantitative, and qualitative aspects of the table are disregarded. For the chemistry novice, information shown in the table quickly becomes overwhelming, uninviting, and cryptic.

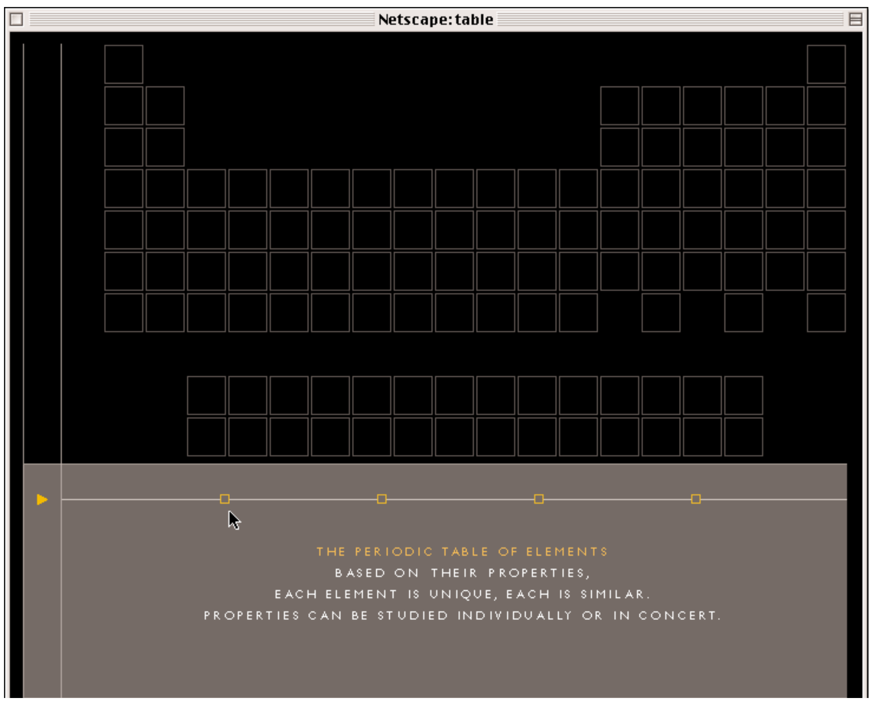
This study explores improving students' comprehension and retention of complex information by translating the periodic table of elements from static to kinetic form. It is designed to help students visualize abstract information by actively engaging them in their learning experience and making use of affordances of digital media. It is also aimed at helping them understand the interconnectedness of complex systems by translating numerical information into visual, aural, and kinetic patterns that can be detected and compared. I hope users will be able to apply this form of learning to other quantitative data as well.

The study, comprised of multiple graphic and auditory transitions which users uncover, is designed to encourage exploration of the interface in a playful manner. In the process, users retrieve qualitative information which can be compared and contrasted. An important feature of the study is its customization of choice; users have the ability to select various points of entry, control the amount of information shown at any given time, and alter the duration of the experience. The neutral appearance of the interface allows users to focus on the actions being performed rather than their surroundings, thus reducing 'information overload.' The minimal use of text is aimed at limiting the need for a written language.

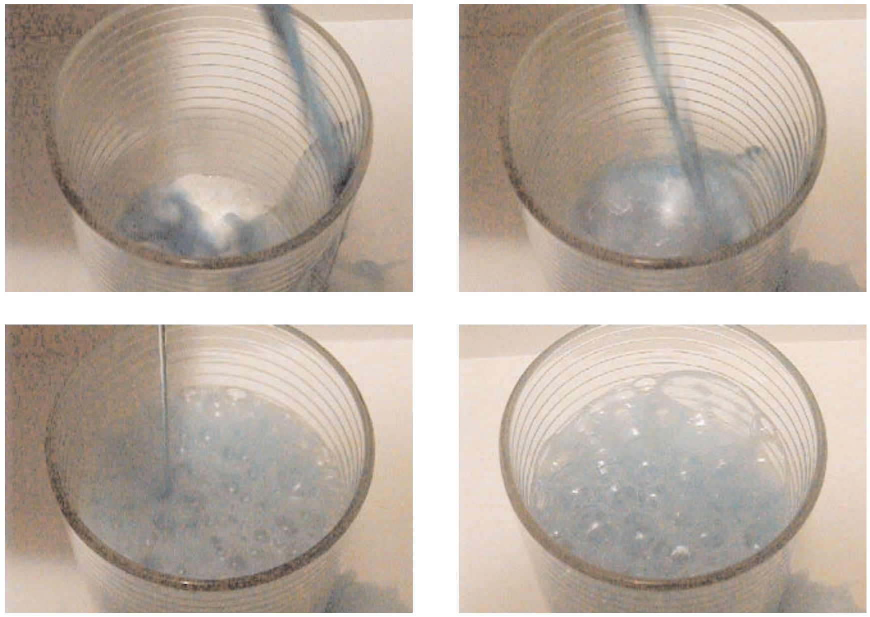
The periodic table, commonly used to teach chemistry, is characterized by complex, abstract numerical data.



Viewers receive only necessary information upon entering the digital periodic table study which encourages their focus on the interactive blinking squares and reduces information overload.

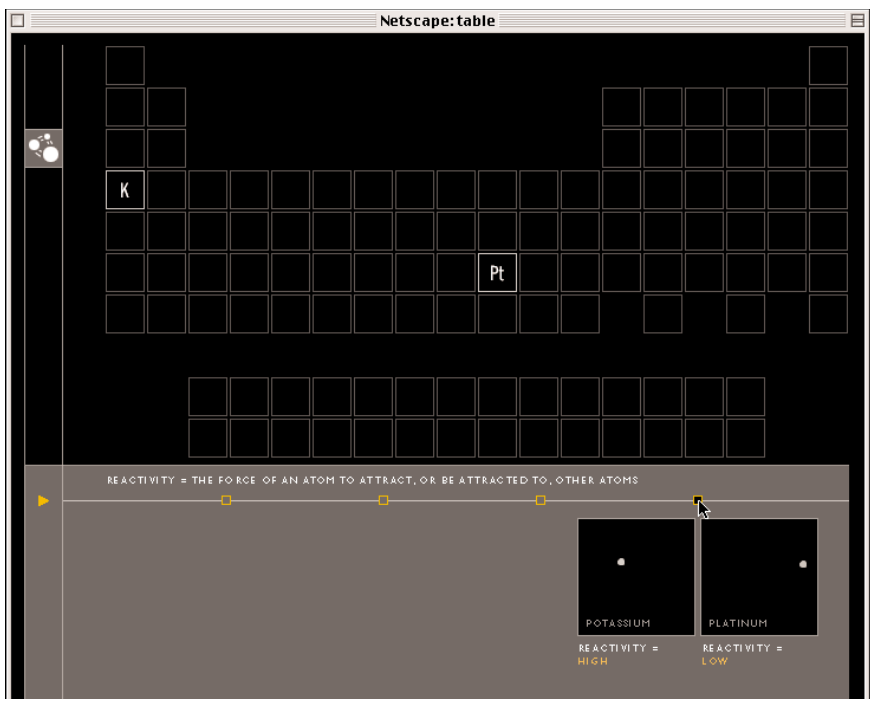


As part of my exploration of representational forms, I used video clips to describe characteristics of the periodic table in a literal manner. In this example, vinegar poured into a glass containing baking soda represents reactivity through quickly rising bubbles.

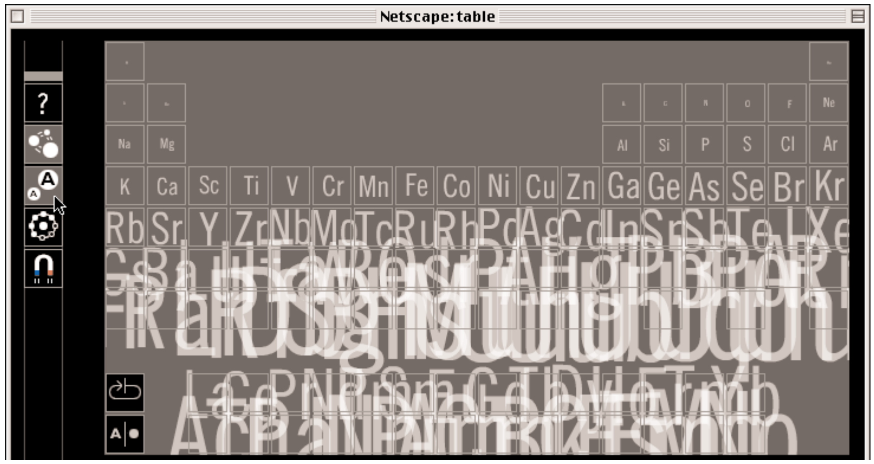


Once realizing that the glass and its contents draw more attention than the reaction occurring, I extracted important characteristics of reactivity and applied them in abstract forms. Therefore, reactivity is represented by dots moving at different speeds and is reinforced by a similar static icon.

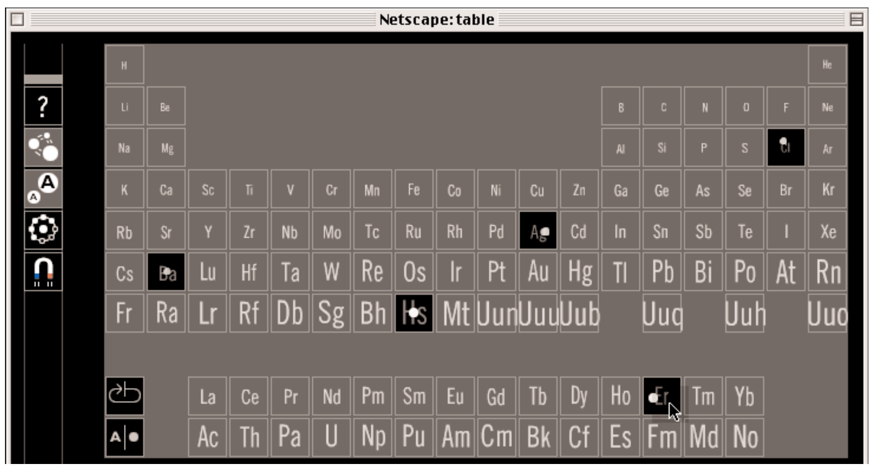
Throughout the study, repetitious squares shown over time are used to access information and encourage viewers to focus on different areas of the screen. Rolling over one of the small, blinking squares highlights two squares in the table. Illustrated in two large squares below the table, the pronounced elements are used as qualitative descriptions of quantitative information.



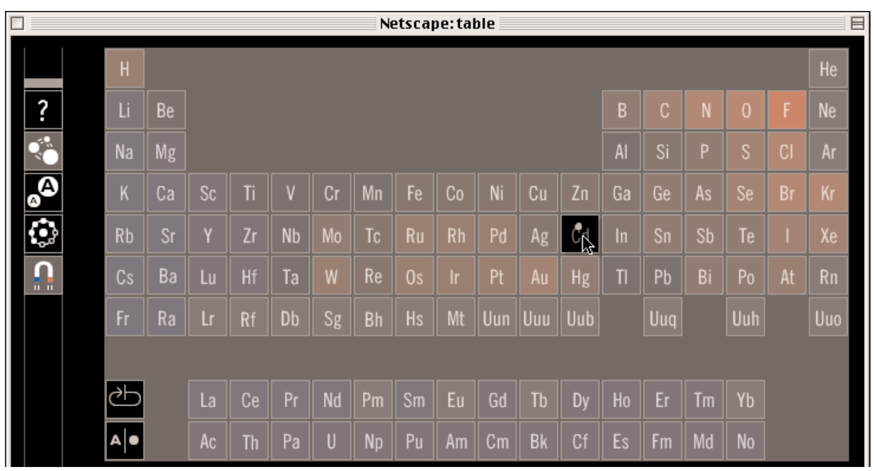
By clicking on the atomic mass icon, viewers see element abbreviations temporally change in scale to match their atomic mass values—moving from letters of consistent size, to accurate representations, to sizes that enable comparisons to be made.



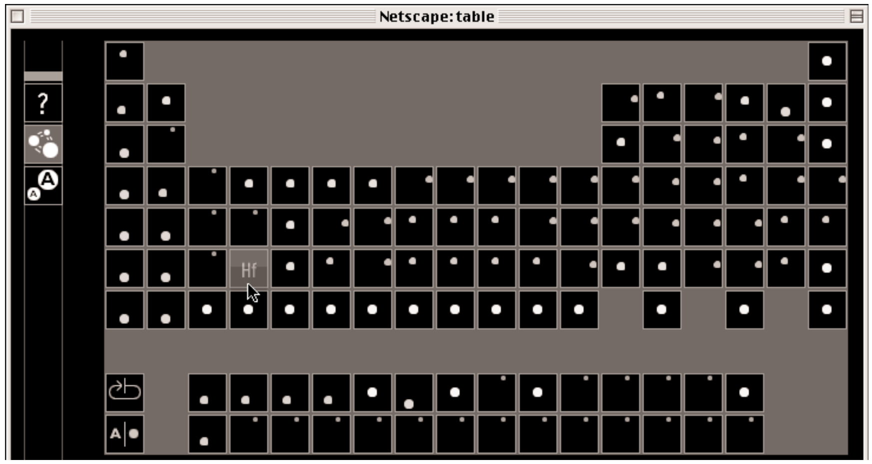
Multiple channels of information can be viewed simultaneously. In this case, atomic mass is represented by the various sizes of element abbreviations and the reactivity of several elements is visible.



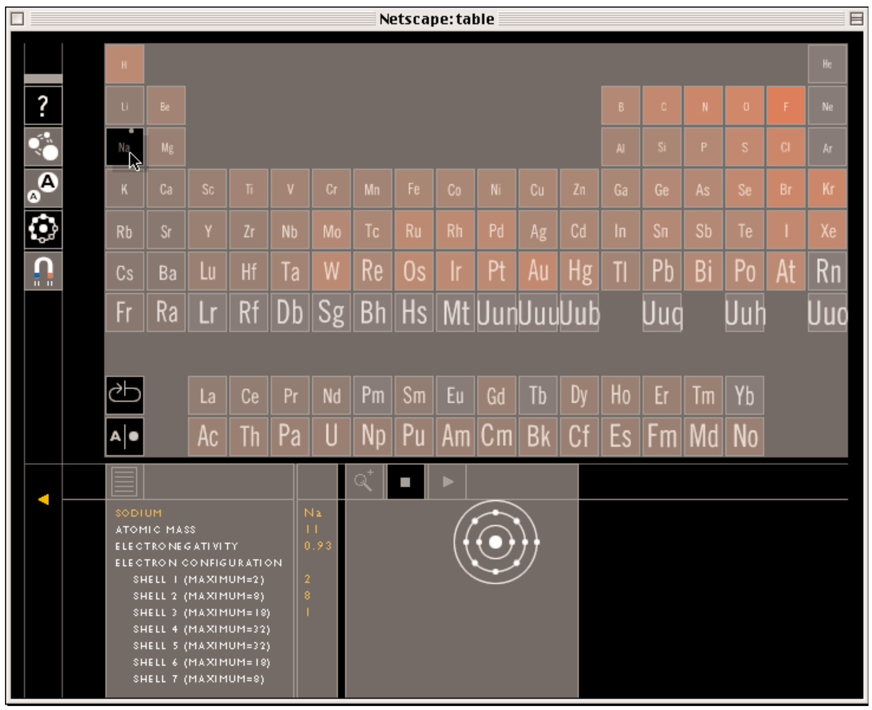
The electronegativity levels of elements are represented by various percentages of red and blue. Color signifies greater and lesser amounts of electronegativity relative to the element selected.



Dots, which represent each element, are grouped with those that share similar reactivity values and hence move at the same speed. Groups having lower reactivity values move more slowly than those with higher values. When the reactivity representations of all elements are visible simultaneously, patterns are revealed and comparisons can be made.



Qualitative representations — in this case, scale, movement, sound, and color — used to describe information are reinforced by quantitative data shown in the two rectangles below the periodic table. The quantitative data provides exact figures for the concepts illustrated.



PROJECT 2 | INHALING HELIUM

How can abstract information that is processed reflectively, become concrete and experiential?

PROJECT DESCRIPTION

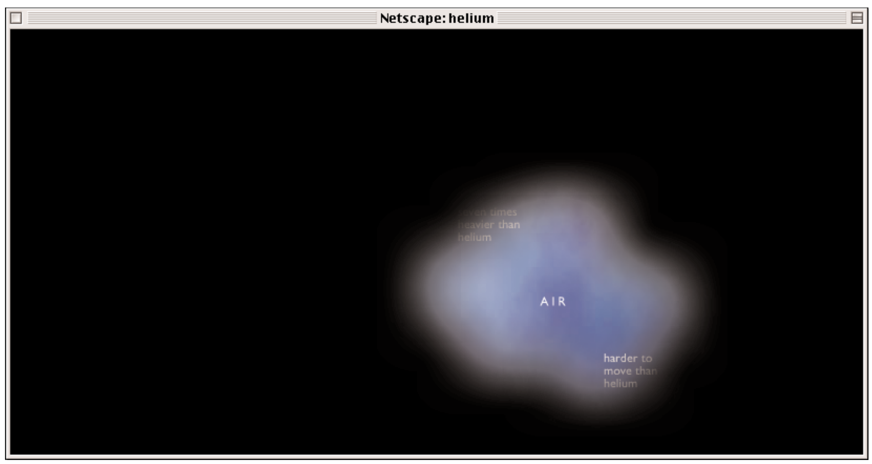
While studying cognitive issues and designing digital learning environments at the same time, I developed this project as the first of several that explored the relationships between design and cognition. The goal of the study was to explain a scientific phenomenon or historical event in a way that privileges direct experience (physical action, sensory input, emotional response, recall of a personal experience or analogy) over theoretical explanations. Although the project was short, I developed an interest and gaining an appreciation for the use of direct experiences, and discovered the relevance and value of integrating them into my final project.

Congruent with this study was an investigation of learner types. In her book, *The 4MAT System*, Denise McCarthy explains that everyone has learning preferences that can be plotted along two axes—perception of information (which ranges from abstract and concrete) and processing of information (which ranges from active and reflective). The majority of education accommodates learners who perceive information abstractly and process it reflectively. For example, scientific and historical concepts are often presented abstractly in the form of written text or static diagrams describing concepts and theories; both forms are processed by thinking about the information. For students who prefer to learn concretely and actively, understanding these concepts can be a daunting task.

Explaining the voice change that occurs when a person inhales helium as the content, this study attempts to accommodate the needs of multiple learner types by combining characteristics of each preference. It is composed of two distinct sections. The first conveys the physical properties of air and helium. On one side of the screen, the cursor, replaced with the word 'helium', seems to move more quickly across the sky-like background than does 'air', on the other side of the screen. Mouse movement reveals information about each gas. Users are able to compare air and helium both kinesthetically and textually. The second section attempts to convey the scientific explanation for how helium changes the voice by integrating data with imagery and sounds that typically surround the situation. This helps viewers recall similar experiences in the real world. Once again, mouse actions are meaningful. In this case, the depression of the mouse determines the length of time for inhalation.

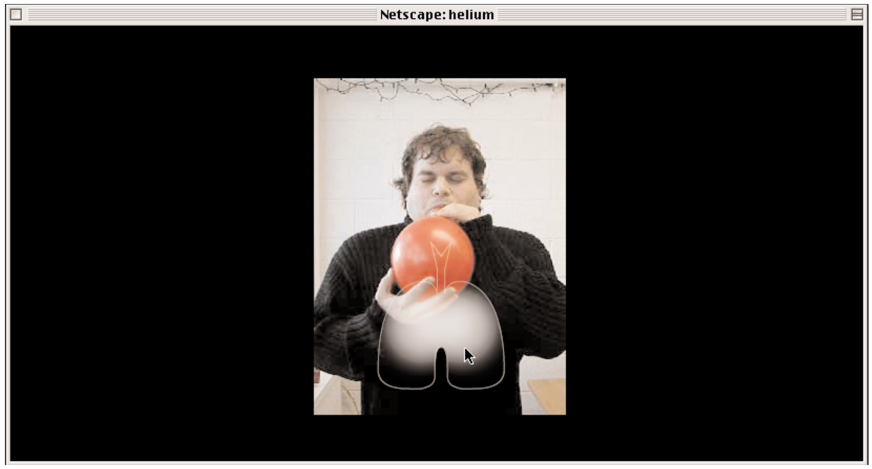
Viewers sense the weight of helium by moving their cursor, which is replaced by a horizontally-elongated shape and the word helium, around the screen. Since helium is light, the sky-like image in the background moves quickly downward, giving the illusion of little weight by making the shape appear as if it is floating. During the process, text describing the characteristics of helium is discovered

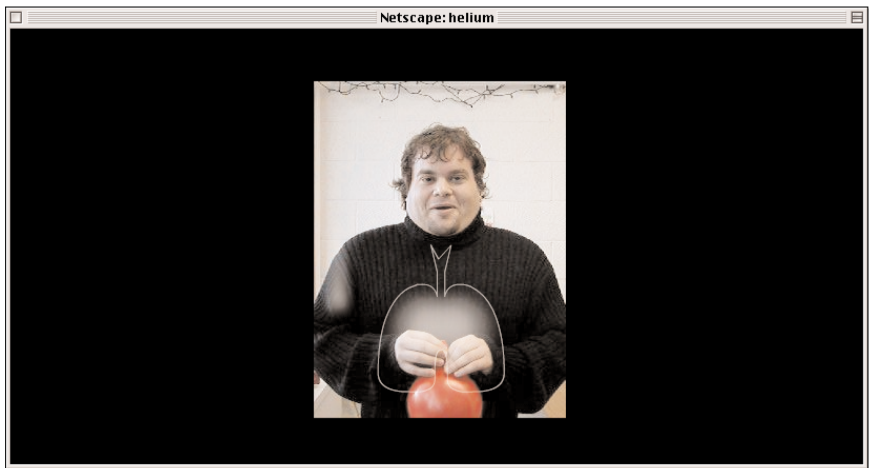
Air is represented on the opposing side of the screen. A vertically-elongated shape and a sky-like image move slowly upward, enabling viewers to feel the heavier weight of air. Once again, text describing air is uncovered in the process of exploring.

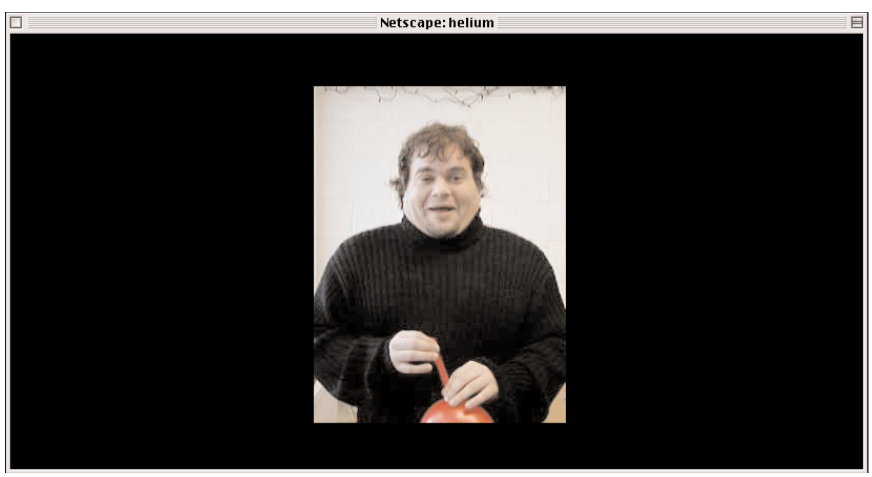


Viewers interact with figures by pressing the mouse while the cursor is on their bodies. The duration of the click determines the amount of helium or air one inhales. Upon release, the larynx moves, sound waves travel, and explanations appear which describe the process.

Discovering that the graphic figures detach viewers from the experience by not representing the activity as a real life situation, I replaced them with a video clip of a real person looking directly at the viewer. Since the situation is typically comical, sounds of people laughing off screen accompany the images. Stills illustrate helium being inhaled, followed by speaking and laughing.







PROJECT 3 | ANIMAL LOCOMOTION

How can patterns be used to represent the locomotion of horses from multiple points of view?

SUBPROBLEMS

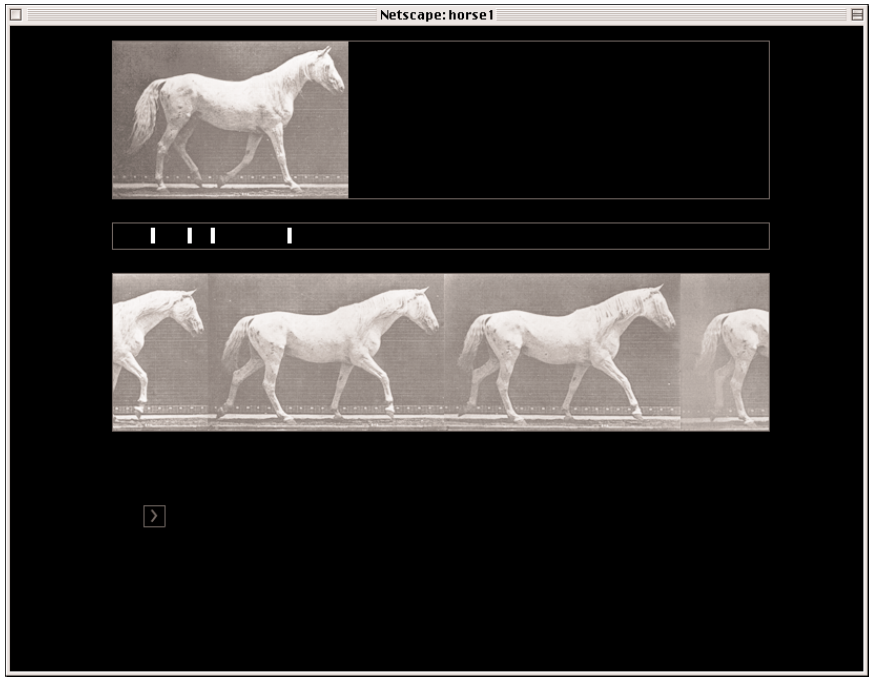
> What can viewers gain from patterns depicting movement from different points of view—some of which are hidden during first hand observation?
> How can motion be described to enable pattern detection and decoding?
> How can the representation of information encourage experiential learning?

PROJECT DESCRIPTION

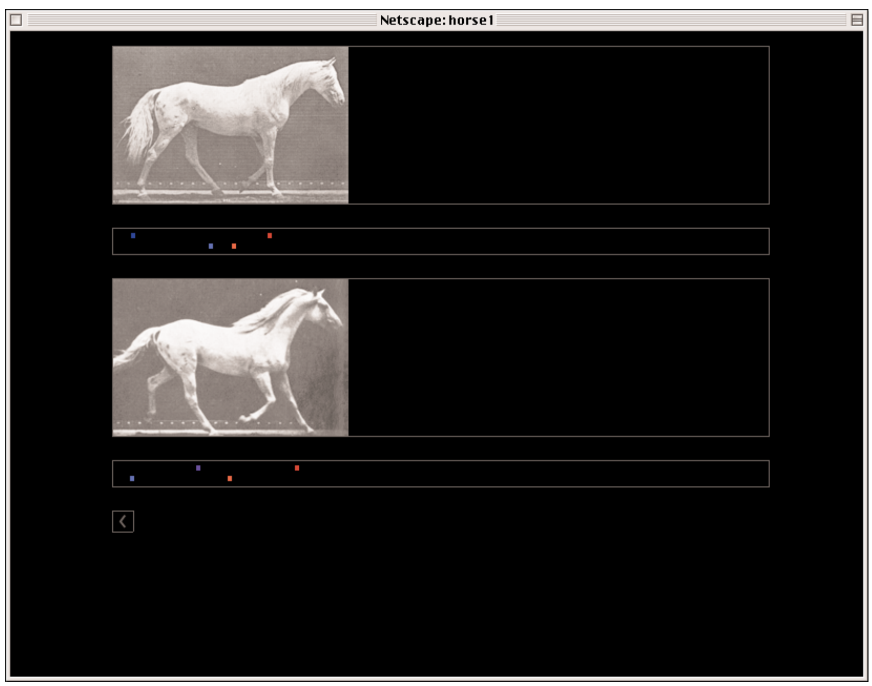
In each study, for the sake of consistency, I looked for content that was scientific, but offered different types of patterns to explore from earlier studies. In this case, animal locomotion provided a repetitive set of movements. Specifically, examining horses gave me content that occurs too quickly to be perceived naturally and compared, and the mechanics of movement are hidden. The purpose of the study wasn't to tackle complex information that is difficult to conceptualize but rather to explore the connection between form and content in representation.

As a starting point, I studied Muybridge's photographs of horse movements, investigating the differences between still frames and motion. Taken in 1878, Muybridge's photographs were the first successfully published serial images of fast motion. I applied simple patterns to the images in an interactive environment, allowing users to turn them off and on. The patterns of position and images became important when trying to make comparisons. In a second attempt, I explored the use of transparency by allowing users to drag both the patterns and images on top of one another too and have multiple items present at one time. Speed control is also an option in this study, enabling comparisons to be examined more easily. Unfortunately, due to time constraints, the digital environment kept me from thoroughly exploring the representation of patterns. I decided to create a series of print-based flip books that explored both abstract and literal representations of movement and various points of view. They enabled me to study the results of combining patterns. I discovered that layering several patterns of information simultaneously functioned similarly to print, often making important nuances indiscernible.

Using Muybridge's photographs of horse movements as content, I compared stills to motion, attempting to determine whether or not one form describes the occurrences better than the other. I explored the use of various graphic elements which match the position of the horse's legs in motion, studying the effectiveness of patterns. The simple representation of information enables viewers to focus on the pattern activity rather than the appearance of the interface.

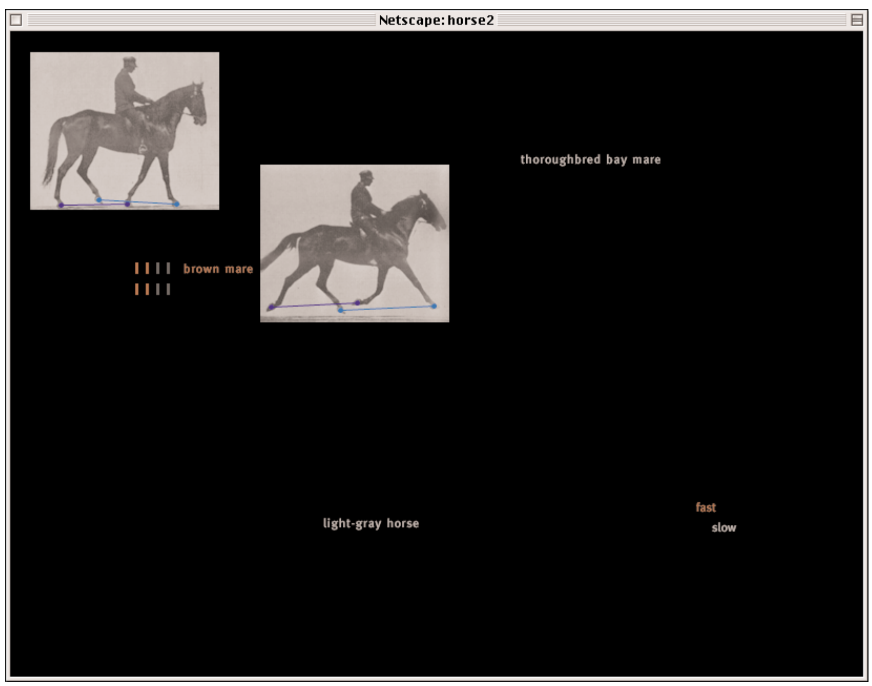


In this example, the movement of a walking horse is juxtaposed to that of a galloping horse. Graphic elements that match the placement of each horse's legs enable formal patterns to be compared. Color and value distinguish the front legs from the back and left legs from the right.

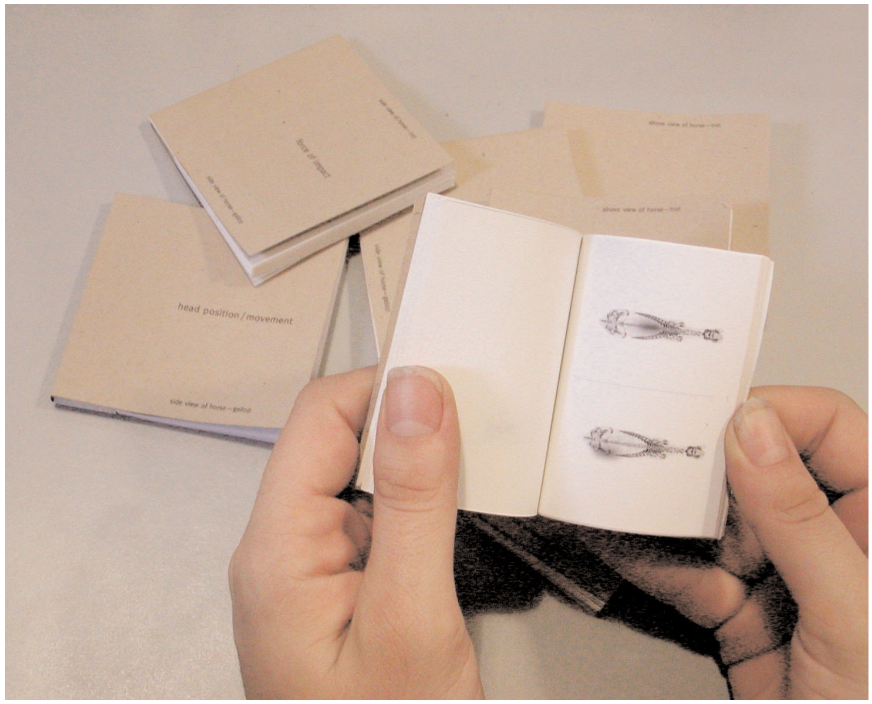


The previous study lead me to discover that the speed and placement of images affects the way they are read and understood in relation to one another. Therefore, this investigation enables viewers to layer semi-transparent images, making the similarities and differences between the horses' movements more evident. By clicking on 'slow' viewers can also reduce the speed at which things move.

Similar to the previous study, viewers see graphic elements that match the placement of the horses' legs while in motion. However, in this example, the graphics are layered directly on top of the images, making the correlation stronger.



When flipped quickly, images printed on pages of books give the illusion of motion. By constructing a series of flip books that explore various ways of representing patterns in horse movements from different points of view, people gain an understanding of parts to whole relationships by comparing views and content.



Two pages from separate flip books illustrate changes in patterns. In the first set, the position of the legs is the only information that changes. However, in the second set, the positions of the jockey, horse, and background change, making nuances more difficult to see.

PROJECT 4 | CELL DIVISION

How can Mark Johnson's description of scripts, explained in *The Body in the Mind*, influence the representation of cell division and transformation in a digital, interactive environment?

> *"A script is a predetermined, stereotyped sequence of actions that defines a well-known situation."* (JOHNSON, P.44)

SUBPROBLEMS

> What characteristics of cell division and transformation are comparable to the scripts Johnson describes?

> How can the characteristics be visually, spatially, and temporally represented through pattern?

> How can patterns encourage the cross-referencing of information?

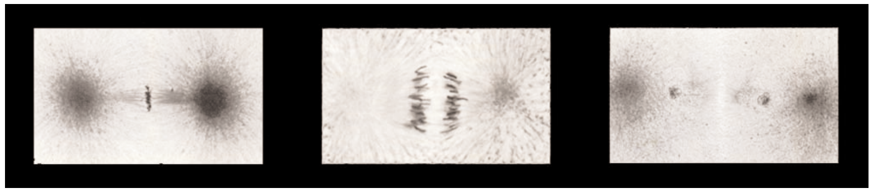
PROJECT DESCRIPTION

The gradual change in form over time that is characteristic of cell division provided a pattern different from those I had studied thus far. The fact that cells are composed of systems within systems, continuously transforming themselves, and are invisible to the naked eye, provided new issues for me to explore. The purpose of the project was to study digital movement, understand its communicative strengths and weaknesses, and explore modes of representing objects in motion.

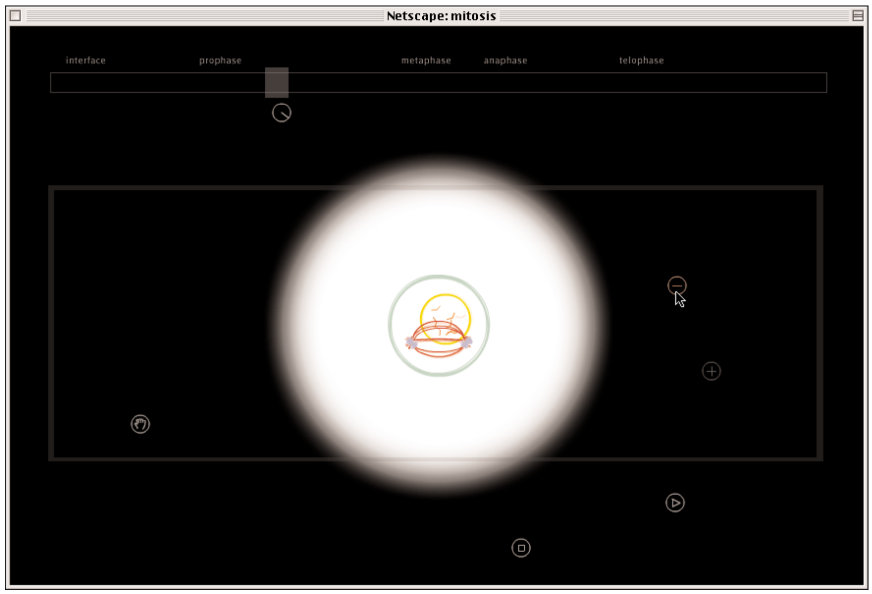
The study content stemmed from a static diagram, typical of science textbooks, which illustrates the process of cell division. Due to the static nature of the cell division diagram, I realized that the transformation that occurred between each step was lost. Also, as the components of cells continually change over time, they need to be labeled in some form for the diagram to be clear. The static diagram fails to achieve this and doesn't indicate that each cell continues the process of division over and over again.

All of the shortcomings of the static diagrams were areas I hoped to improve upon by emphasizing pattern and motion. I began to explore the relationship of schemas to cell division by applying fundamental movements people recognize to the representation of cells. Realizing that the information is fairly abstract and indiscernible, I determined that the path to the content was extremely important. Through trial and error, I also discovered that interaction with objects is more interesting, engaging, and less cumbersome than interaction with tools.

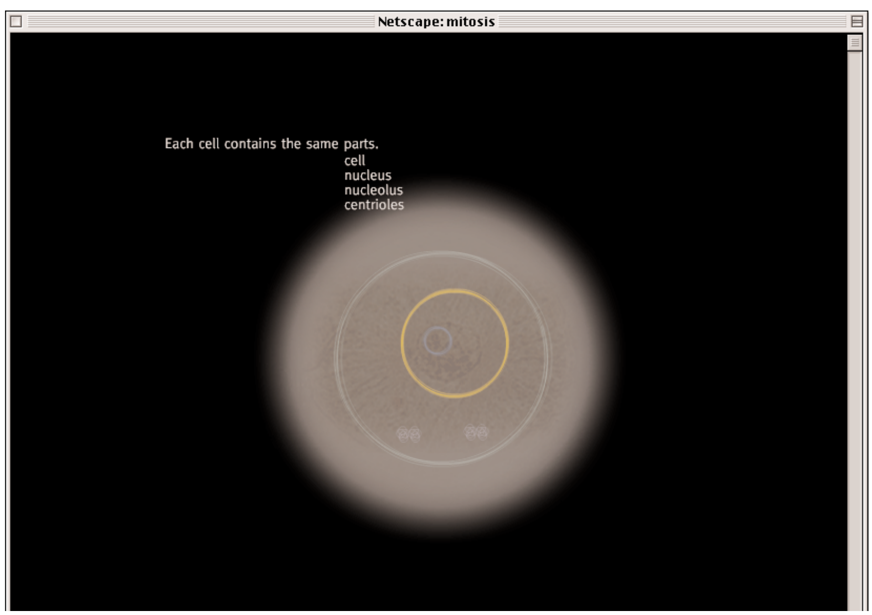
Textbooks typically explain the process of cell division by illustrating temporal events in a static form. Unfortunately, components are hard to see, making the comparison of stages difficult.



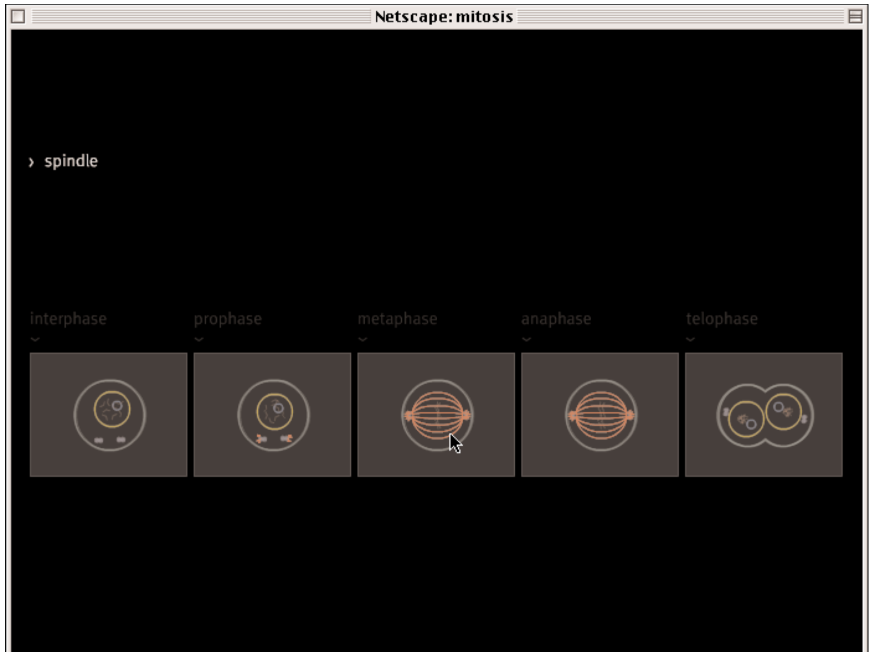
My first attempt at representing the process of cell division includes buttons that viewers use to move through and scale objects. Viewers can also control the layers of information visible and the speed of motion.



Matching the tools used to see objects that are invisible to the eye by visually representing a microscope, viewers correlate digital images to known schemas. Photographs of cell components are gradually replaced by graphic representations of those forms which enable viewers to see patterns and make comparisons.



Since buttons are cumbersome and often redundant, the objects of the interface are used as tools. By moving the mouse over components of the cell, identifying text appears.



In this example, the screen area is used as a scaling device. By placing the mouse in the top portion of the screen, the animated cell becomes larger. Movement to the bottom of the screen reduces the size of the cell.

PROJECT 5 | GLOBAL WARMING

How can diagrams be used to represent the cause/effect narrative that describes global warming?

SUBPROBLEMS

> How does the representation of factual information differ from speculation?
> How is the overlap of effects—direct and indirect—represented?
> How can usage patterns be visually, spatially, and temporally represented?

PROJECT DESCRIPTION

The study of global warming provided a unique set of patterns, different from those I had studied thus far. Global warming is the result of cause/effect relationships and interdependencies and is based on facts as well as speculation. Global warming involves the increase and decrease in the state of key factors, such as water levels, which are a result of repetitive events (patterns) that occur over time and affect one another. Global warming contains both direct and indirect effects, some of which are 'hot button' issues, about which there is much debate. The characteristics of this information presented new challenges for me in determining the structure, representation, and path of information, all of which became the focus of my study.

I began the project by gathering data related to global warming and quickly discovered that the information was disjointed and quantities often appeared vague and/or inaccurate. In order to make comparisons, I decided it was necessary to bring the data together into a single communication. For the purposes of my study, I also determined that understanding the relationship of overall increases and decreases in amount was more valuable than exact amounts and, therefore, generalized the varied data I collected.

I created a concept map of my findings, which enabled me to structure the content visually. In doing so, I discovered the non-linear interconnectedness of systems. I began to see global warming as multiple sets of paths that function similarly to narratives. The concept map I constructed, therefore, became an important base in forming the structure of the interactive diagram. Building onto the global warming infrastructure, I attempted to use imagery and sound as a means of encouraging the imagination of concrete experiences.

Concept maps helped me to structure the vast amount of data on global warming.
(NOVAK AND GOWIN P.14)

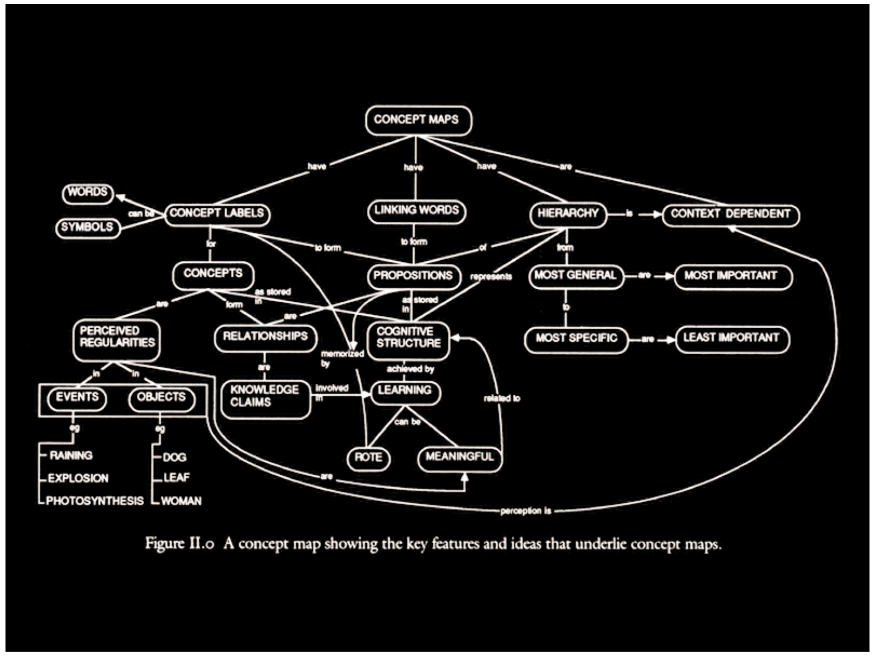
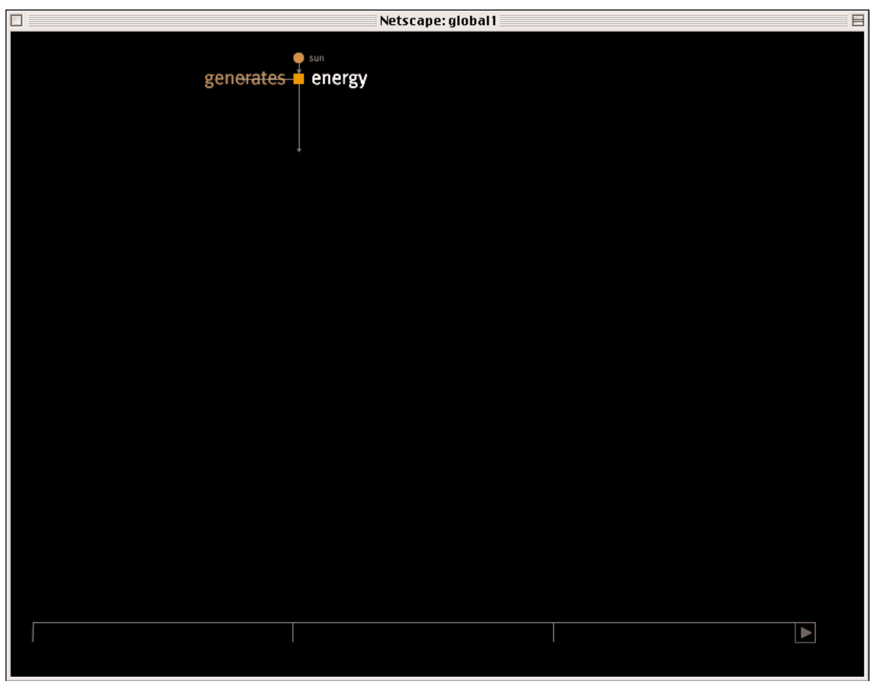
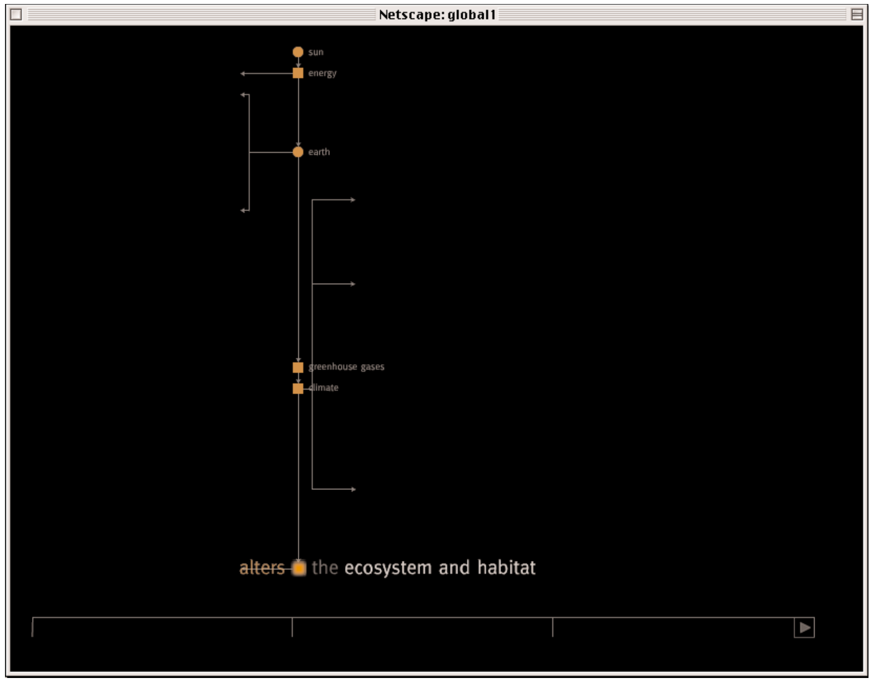


Figure II.o A concept map showing the key features and ideas that underlie concept maps.

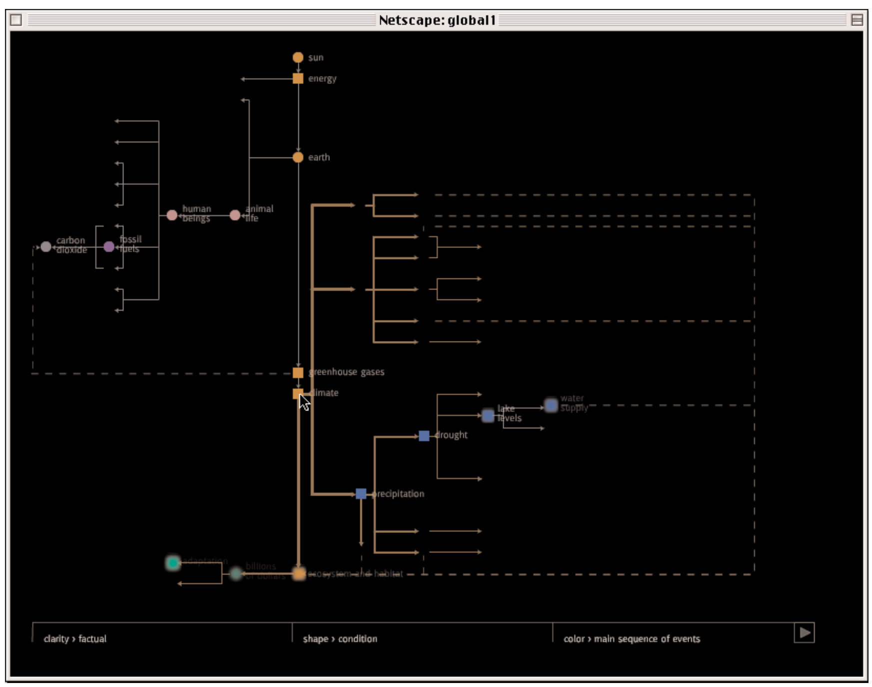
Upon entry, viewers select an arrow prompted by a noun. A verb appears followed by another noun and additional arrows. The temporal building of visual structure on the basis of verbal narrative allows viewers to choose the direction and duration of the narrative.



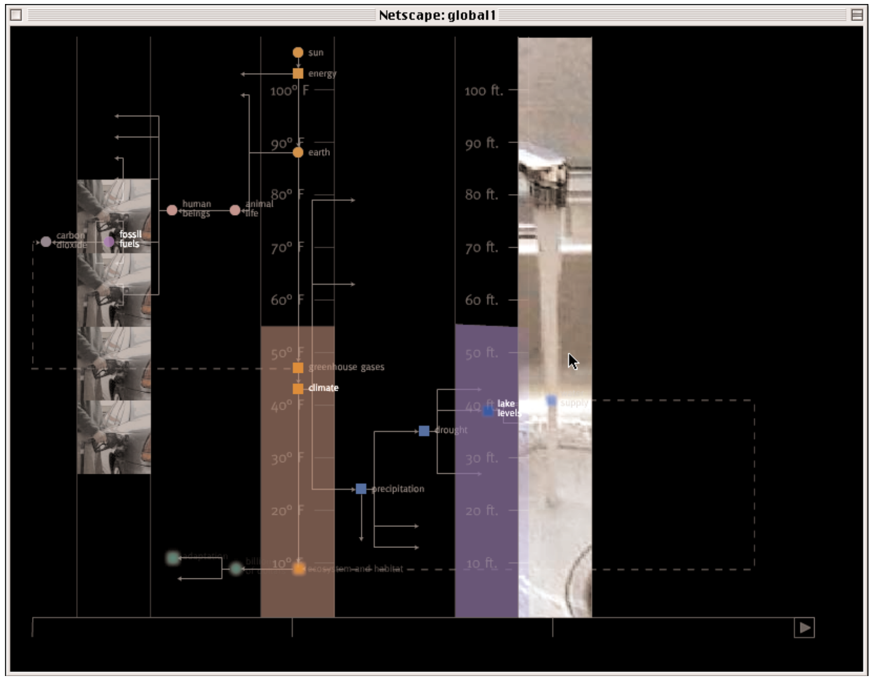
Illustrated are additional steps in the process of constructing the narrative.



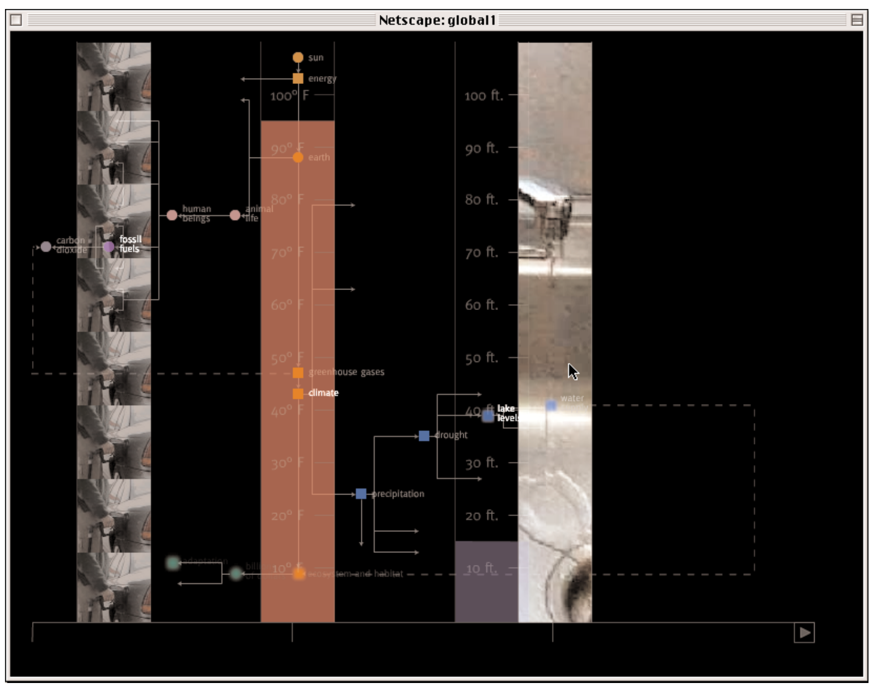
Direct and indirect effects of global warming factors are signified by varying line thicknesses and accessed by rolling the mouse over the squares or circles. At the same time, additional information pertaining to each noun appears at the bottom of the screen.



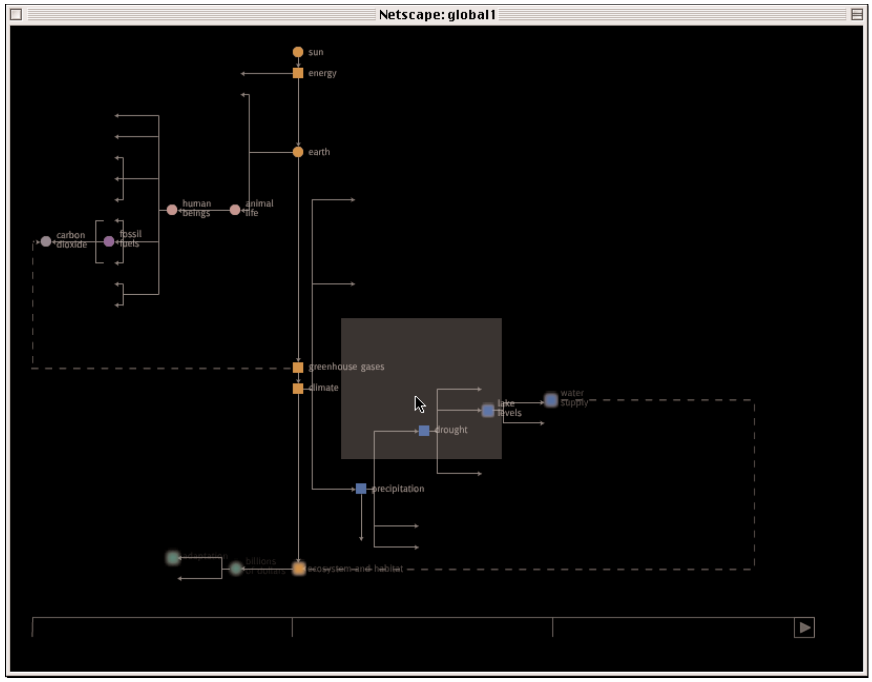
In an attempt to engage viewers in the digital experience by mimicking images people see daily, video clips of common objects are used to convey the connectedness of actors that cause global warming.



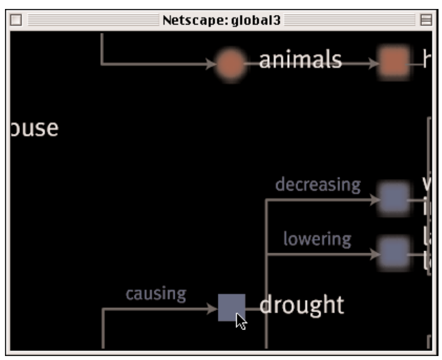
As the number of images of a person pumping gas, (describing the consumption of fossil fuels) increases, the water streaming from the faucet is reduced from a steady stream to a trickle, illustrating the effect fossil fuels have on water supply. As a result, blocks of colors depicting temperature and lake levels are affected in size and intensity.



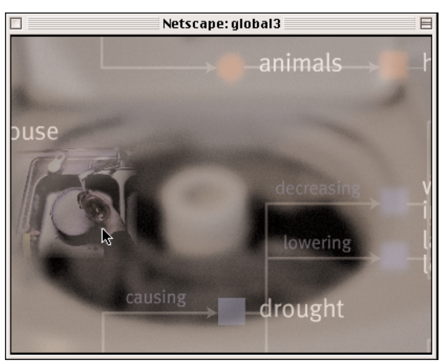
Sections of the interface can be highlighted and enlarged to provide greater clarity.



By clicking on a section of the diagram, an additional window is launched containing an enlarged portion of the image.



Viewers can scroll the image and select any of the nouns to access additional information. By clicking on 'drought', viewers receive moving images of everyday activities that would be affected by a drought and commentary explaining drought conditions.



PROJECT 6 | BIOLOGY/MACHINE

How can the representation of disparate parts (specifically the juxtaposition of biological and mechanical processes) encourage sensory-based comparisons?

SUBPROBLEMS

> How can pacing and simultaneity convey pertinent information?

> How do schemas, which represent viewer expectations, affect the representation of concepts?

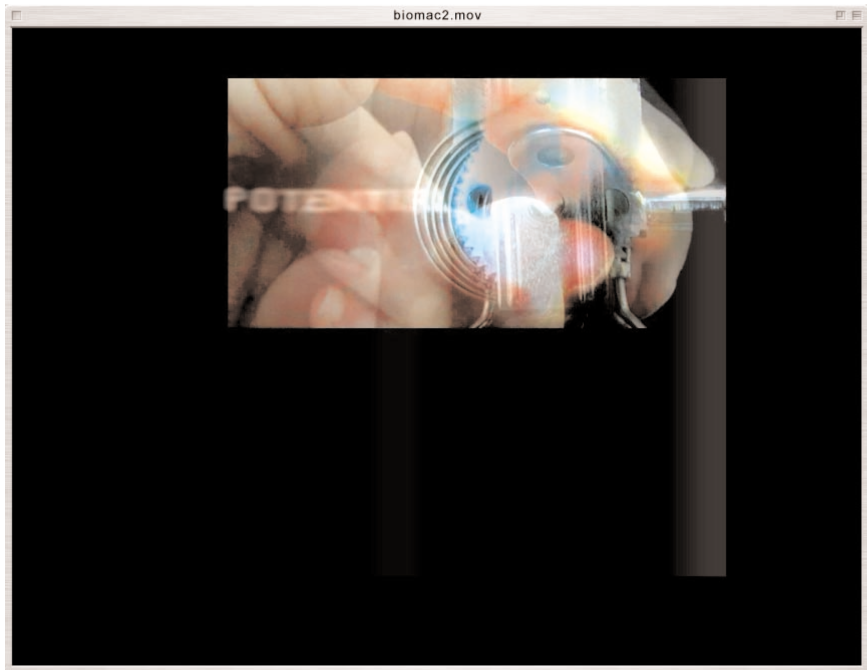
> How can the cinemagraphic representation of concepts reduce the need for physical interaction?

PROJECT DESCRIPTION

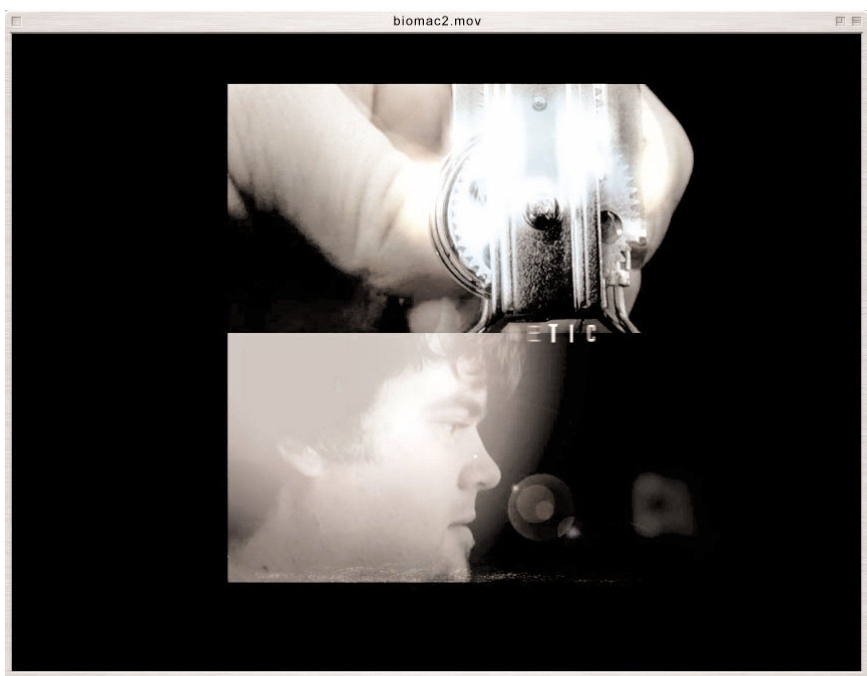
Wanting to investigate a wide range of representational strategies for communicating concepts, I designed this project to illustrate a significant departure from the analysis of scientific information. Energy intake, transformation, and expenditure are difficult concepts for people to grasp because they are highly abstract due to their invisibility. Using a plant and a wind-up toy as content, this project focuses on creating connections between disparate objects that are seldom compared but exhibit similar uses of energy. By viewing the study, I hope that people gain a clear understanding of the transfer of energy and how the compared objects function similarly and differently.

Contrary to my other investigations, this study takes the form of an autonomous movie, not requiring interaction to acquire information. Relying completely on non-textual visual, aural, and temporal, representations to convey meaning was a new and difficult challenge for me. Through several rounds of trial and error, I found that people understand complex concepts best when they are presented as a story. Therefore, I introduced information incrementally, building in complexity over time and functioning as a narrative. In doing so, I discovered the importance of cinematography. Not only do representations of content need to convey pertinent information, they also must create experiences that enthrall viewers. Therefore, representing concepts in a manner that matches the expectations of viewers by visually, temporally, and aurally mimicking schemas, engages them in the sensing of the unfolding story. For example, objects glow and the saturation of their color increases as the energy they retain grows. The sequence reverses as energy is expelled. Digitized images imply mechanical processes whereas natural forms represent organic objects. The use of time also showed me the value of pacing and simultaneity in constructing meaning. Presenting information simultaneously enables comparisons to be made. Plus, pacing is not only an effective way of building messages over time, it also conveys meaning itself. For example, changes in the duration of sounds and images affect the way they are interpreted. In this case the slowing of an object explains the expenditure of energy.

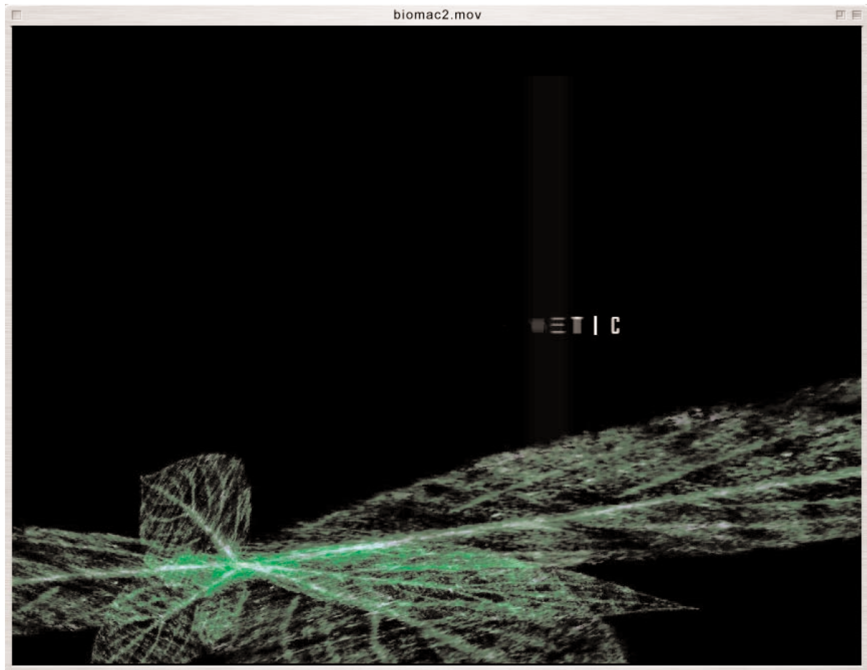
In this example, energy travels from the crank of a wind-up toy through its gears to its counterweight, where it is held. The transformation from kinetic to potential energy is described qualitatively through imagery, sound, and motion.



Viewers see object colors increase in saturation as the amount of potential energy they retain grows. In this case, both images are fairly monochromatic, indicating that neither holds much potential energy. Mechanical and biological objects capture and use energy differently. Juxtaposing the transfer of energy for a wind-up toy with that of a plant enables the energy processes to be connected and compared.



Instead of receiving quantitative information, viewers are given a qualitative description of how plants use energy by seeing leaves grow over time. The plant appears digitized in this example, emphasizing the mechanical processes to which it is compared.



In contrast, the representation of the wind-up toy appears organic, connecting it to the opposed biological process. The toy bounces quickly and sporadically across the screen, illustrating its use of energy by matching viewer expectations of movement. The color of the object becomes less saturated as energy is expelled and the toy's movements become slower.