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Visual Narrative Styles in Mathematics and Computer Science

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ABSTRACT

Traditionally, in technical expository writing, illustrations are treated as adjuncts to the text where the reader is referred to the illustrations by the text which describes or explains the illustration rather than being tightly integrated into the narrative. Recent research in cognitive psychology is producing a new set of guidelines that define how to effectively use illustrations. Based on this research we know that cognitive load is reduced when illustrations are integrated into the text (contiguity principle); extraneous or irrelevant material should be removed from illustrations (coherence principle); multiple representations that engage different parts of the brain improve learning (modality effect); and, use of repetition improves encoding accuracy and transfer to long-term memory (redundancy principle). Using appropriate levels of abstraction and goal free presentations also reduce cognitive load.

With a few notable exceptions, the traditional approach often conflicts with what we now believe to be the best ways to effectively use illustrations. This can be a particular problem in computer science where attention may be split among text, code, and illustrations.

It is possible to develop a visual narrative style that embodies the principles from cognitive psychology. In fact, this has been done informally for centuries (e.g., da Vinci's notebooks), but the approach is still rarely used in formal writing or in published materials. With recent technological developments, such as page layout software and digital ink, the process has been simplified and is now growing in popularity.

This paper reviews the cognitive basis for effectively using illustrations in mathematics and computer science.

Categories and Subject Descriptors

K.3.2 [Computers and Education]: Computer and Information Science Education—*computer science education*

General Terms

Design, Human Factors, Standardization, Performance

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Keywords

Education research, coherence principle, contiguity principle, digital ink, modality effect, visual narration

1. INTRODUCTION

Although it might come as a surprise to someone who hasn't given it much thought, both mathematics and computer sciences have strong narrative elements. The chain of reasoning in presenting a mathematical argument or proof or the description of the execution of an algorithm are common tasks in these disciplines. These tasks are essentially the presentation of a sequence of steps or actions with a clear logical progression, the defining characteristic of a narration.

Moreover, both disciplines tend to be very visual at times, especially during narrations. For examples, figures are used when reasoning about spatial or other relationships. They are often used to provide a useful model abstracting away non-salient details. (Indeed, it could be argued that much of the notation in mathematics can be viewed as idiographic.)

Consequently, in both mathematics and computer science, we often find ourselves presenting a visual narration, either talking with or about diagrams. This raises questions of what the appropriate narrative style should be for this type of presentation, and how illustrations should be formatted, presented, and, integrated into the narration.

2. DESIGN PRINCIPLES

In traditional publishing, illustrations have been treated as separate entities. They are presented along with the text, rather than as an integral part of the narration. This is a natural consequence of the technologies used to create and publish printed materials—an historical consequence of manual typesetting in publishing. While understandable, this has led to a static view of graphics. Illustrations are largely separate from the text. Much excellent material has been written about creating such illustrations, particularly by Edward Tufte. [22, 23, 24, 25]

While quite valuable, treatments that focus on the illustration in isolation, of necessity, don't address the larger context of how illustrations work with text, i.e., how the illustrations integrate into the overall narrative.

2.1 Traditional Design Principles

Traditional design principles are largely intuitive. For the most part this works well, but not always. For example, design principles may be driven more by artistic considerations rather

than practical considerations. This can lead to designs that look good but are difficult to understand. For a specific use, they may be selected in an ad hoc manner and, once selected, applied mechanically. Often only a subset of available principles is selected for use depending on the context. And, as previously noted, they are largely if not exclusively centered on static illustrations. It is ironic how often texts on graphic design can be difficult to read if not ugly. And since design principles tend to be fairly general, they often fail to adequately address problems that are specific to individual disciplines with special problems or needs—disciplines such as mathematics or computer science.

These considerations raise a number of questions. How do you choose among conflicting principles? Are there cognitively-based design principles? And, are there really discipline specific needs and corresponding principles specific to those disciplines?

2.2 Cognitive-based Design Principles

A surprising amount of information is available relating cognitive theory to design. At the risk of grossly oversimplifying this material, this section describes some of the design principles that seem particularly appropriate.

2.2.1 Contiguity

Present related material together, both spatially and temporally. This is a direct consequence of the *Split Attention Effect*. That is, there is an increase in cognitive load if attention is divided among different tasks, and this increased cognitive load makes learning more difficult. For example, when the reader must move repeatedly between an illustration and the text that describes or explains the illustration, they have to work harder. [10, 14, 15] Unfortunately, this is exactly what modern publishing practices mandate—illustrations presented apart from the text that explains them.

2.2.2 Coherence

Avoid extraneous or irrelevant material in a presentation, e.g., illustrations used as decoration or decorative features within an illustration. This is also a consequence of the *Split Attention Effect*. [14, 15, 18] (Fortunately, this rarely seems to be a problem.)

2.2.3 Abstraction

Use an appropriate level of abstraction to reduce cognitive load. This effectively hides extraneous information allowing the reader to focus more closely on the salient details. [18] (This closely matches the software design principle of information hiding, an idea that should be near and dear to any programmer.)

2.2.4 Building on Existing Knowledge

So that material can be acquired more quickly, build on existing knowledge and clarify the relationship between new material and existing knowledge. Worked examples and completion problems are particularly helpful. [20] There is an obvious connection between this principle and the previously stated principle of abstraction. [16, 18]

2.2.5 Complexity

Reduce complexity. Provide visual clues to assist the viewer in finding relevant content in illustrations. (This is more important for low-knowledge learners than high-knowledge learners and more important when working with high-spatial content than low-spatial content.) [21]

2.2.6 Goal Free

Use less specific goals to reduce cognitive load, i.e., the dependence on short-term or working memory. By reducing constraints, there are fewer specifics to keep in mind. Removing the goal, in the short term, allows the reader to focus on what is known and on interrelationships. [18] (This admonition brings to mind Polya's admonition, if you can't solve the existing problem, can you solve a related problem? [17])

2.2.7 Multiple Representations

To improve learning, use multiple representations that engage different parts of the brain. Text is thought to be processed largely in the audio processing parts of the brain while illustrations are processed in the brain's visual centers. Using both illustrations and text engages different parts of the brain and creates multiple links to the material. This is a consequence of the *Modality Effect*. [9, 14, 15] (And, in particular, illustrations tend to be easier to remember than text. This is known as the *Picture Superiority Effect*. [9])

2.2.8 Redundancy

Use repetition to improve encoding accuracy and transfer to long-term memory. [14, 18] Despite what we may wish, there is still virtue in repetition and the old adage, "Tell them what you are going to say, say it, and then tell them what you just said".

2.2.9 Constructivism

As a teacher, adopt a role of support where learning is initiated and directed by students. Learning improves when the learner controls the pace. (The latter is also known as the *Pacing Principle*.) Once again, this is a principle that engages the student. [14, 18] (Superficially, at least, this argues for separate illustrations where the student can determine how closely they want to study the illustration.

2.2.10 Personal

Use first person in narrations. This reduces the perceived distance between the author and the reader. Consequentially, the reader is more engaged. [18]

To be sure, a much longer list could be constructed. But these examples suffice to make several reasonable observations. First, even the casual reader will note that there are a few underlying criterion on which these principles are based. Specifically, limited working memory makes it difficult to process information simultaneously. Yet, when these elements are interrelated, they must be processed simultaneously. This increased cognitive load may be reduced by the appropriate presentation of material. Reducing cognitive load and engaging the learner are core criterion on which most, more specific principles can be judged. This gives us a useful basis for selecting among conflicting design principles. [19]

A second observation is that collectively these design principles argue for a narrative style in which illustrations are embedded within the text, the major thesis of this paper.

2.3 Caveats

A few words of warning are also appropriate. These principles are very context and goal dependent. In practice, it is necessary to use these principles selectively based on specific pedagogical goals. For example, there likely comes a point where cognitive load is reduced to the point where the reader is no longer engaged but is, in fact, easily distracted. Moreover, we can certainly

oversimplify material so that, in modern educational parlance, the learning experience is no longer authentic. That is, learning becomes so divorced from reality that the way the student learns is only remotely related to how the student will need to function in the workplace. Still, these principles do provide a useful starting point if not overstated.

3. An Example—Linked Lists

As noted above, collectively these guidelines imply that figures should be directly integrated into the text to reduce cognitive load and make material easier to follow. At this point, it may be worthwhile to look at an example of how this might be done.

In computer science, we frequently use a construct known as a linked list to store and organize data. In a linked list, data is scattered throughout the memory of the computer. The address or location of the next piece of information is stored with each piece of information. By following this chain, we can traverse the linked list and access all the data in the structure. By altering the address stored with a piece of information, we can change the structure of the linked list, e.g., the order of the data within the list.

To discuss linked lists, computer scientists frequently use a graphical notation known as *box-pointer diagrams*. A two compartment box is drawn for each piece of information in the list representing a chunk of computer memory. The information is placed in one compartment and an arrow (representing the address of the next box) is drawn from the second compartment to the next box along the chain. That is, the arrow visually represents the link to or the address of the next item. (Examples of box-pointer diagrams are shown in Figure 1.)

In a typical presentation, we will have up to three narrative elements—the text describing the operation, a separate figure or figures showing the changes in the box-pointer diagram, and a third figure showing the actual code that is used to make the changes. Thus, the reader will then have three elements competing for his or her attention. The reader might first look at the text, then the illustration, jump to the code, back to the text, etc., as they make their way through the narration. (And if the code is heavily commented, a fourth element is introduced as the reader shifts between actual code and the embedded documentation or comments.) Clearly this mode of presentation splits the reader's attention and adds to the cognitive load. And all too often, some readers will ignore one or more elements.

An alternative is to embed the figures and code within the text to produce an integrated narrative as shown in Figure 1.

To be fair, many texts do include snippets of the code within text. This is easy to do since code is basically just text. But the figures are rarely included directly in the text. Worse still, the sequence of figures is often reduced to a single figure, perhaps with parts that must be decomposed and matched to the narration.

(Also, it is worth noting, that while the code should be embedded in the text, it is important to reproduce the final completed code, probably as a separate figure. Reading code directly is an additional skill students should master. Thus, it is not reasonable to try to embed everything.)

4. Visual Narration in Practice

For pragmatic reasons, the opposite approach has traditionally been used—illustrations have been treated as separate entities. With mechanical typesetting, it is easy to see why figures and

Adding a new node at the end of a linked list can be thought of as a three-step process.

The first step is the creation and initialization of the new node. The pointer in the new node should be set to NULL and the data should be copied into the node.

```

/* create and initialize node */
tmp = malloc(sizeof(*tmp));
tmp->datum = newData;
tmp->next = NULL;

```

The next step attaches the new node to the list. If the list is empty, the pointer to the head of the list is set to point to the new node.

```

head = tmp; /* if list is empty */

```

We go from

to

If the list is non-empty, the pointer in the last node in the linked list is changed so that it points to the new node.

```

tail->next = tmp; /* if list is not empty */

```

That is,

The code, of course, must distinguish between these two cases.

```

/* add to linked list */
if (head != NULL)
    tail->next = tmp; /* if list is not empty */
else
    head = tmp; /* if list is empty */

```

In the final step we change the pointer to the end of the list so that it now points to the new node.

```

/* update pointer to the tail of the list */
tail = tmp;

```

For an empty list, the final result looks like this:

For a non-empty list, it should resemble this:

Figure 1. Embedded figures and code.

illustrations had to be treated differently. This has created a traditional approach that has been preserved even as technology has moved beyond the constraints that defined the original approach.

Of course, there have been numerous exceptions over the years, and exceptions are becoming much more common. It is worth looking at some of these with an eye toward how they fit into our

cognitive design principles and, where feasible, the technologies that enable these alternative approaches. Unfortunately, only a few examples can be presented here due to both space and copyright restrictions. But these should serve to convey the general approach argued for in this paper.

4.1 Cells

In some disciplines, such as literature, most items of interest can be easily embedded in text because they are text. A writer can simply quote Shakespeare directly in the body of the text. In some cases special fonts may be needed, but this is a minor problem today. As noted, in computer science, snippets of code are easily embedded, at least for most programming languages. It is nice to be able to color code text to differentiate different syntactic features. Although labor intensive, this is certainly feasible although rarely done due to the cost of color printing. (As electronic publishing becomes more popular, we should be able to easily move beyond this limitation.)

Mathematics provides a particular challenge. Typesetting equations has historically been a costly, labor intensive, and error prone activity. The emergence of typesetting languages specifically for mathematics, most notably TEX, has started to change this. Nonetheless, there is still a tendency to separate the text from the mathematics alternating between text and equations. For example, the notebook model by Mathematica[®] uses this approach. In a Mathematica[®] notebook, both text and computations are included, but they are entered in separate cells.

Abraham's and Shaw's book on dynamics [1], published in the 1980s, takes the approach of dividing a presentation into a sequence of cells to an extreme. In this text, the presentation of the material is organized around the copious use of figures. There is very little free standing text—most of the narrative is integrated into the captions for the figures.

Another effective use of a more visual approach is that used by Larry Gonick in a variety of fields. [7, 8] His *Cartoon Guide to Statistics*, for example, fully integrates text and graphics in what looks to be comic book (or, if you prefer, a graphic novel). [8]

(A surprising amount has been written about the craft of writing comics, most notably, the writings of William Eisner and Scott McCloud, but others as well. Collectively, Eisner and McCloud outline a possible semantics for comics as well as discussing the general craft. [2, 3, 6, 11, 12, 13] The reader interested in this approach would do well to look at some of these texts.)

In computer science, the *Little Lisper*, along with numerous similar books, has taken a cellular approach. [5] Such books are very reminiscent of the programmed learning texts that were once popular.

4.2 Moving Beyond Cells

A somewhat different approach is taken in the *Head First* series published by O'Reilly Media, Inc. In the general introduction to the series, replicated in each book, they lay out their general approach which includes combining text and graphics and using a conversational, first person narrative to more fully engage the reader. [4] Indeed, the O'Reilly series comes very close to the guidelines described here. On the down side, the O'Reilly text consistently introduces extraneous, irrelevant, and distracting graphics in an effort to lighten the text and make it more readable and engaging. And to an extent, their presentations seem to be designed for a short attention span that brings to mind the cellular

approach just described. Nonetheless, some readers may find this engaging, and consequently, effective. Initial reports from instructors using these books as textbooks have been favorable.

4.3 Current Technology

A key requirement for a more visual narrative style is the availability of appropriate technology. This requires both appropriate hardware and software. Software might be as simple as a word processing program that can embed images, but better results will be possible with page layout software such as Adobe[®] InDesign[®]. (While expensive, steep educational discounts are available.) For example, authors for the O'Reilly series often use InDesign[®] supplying the publisher with "camera-ready" copy. [26, personal communications] Additionally, programs to create or edit graphics, such as Adobe[®] PhotoShop[®], can be used to alter or cleanup images.

For the actual artwork, the simplest approach is to rely on clip-art. In general, this is not very satisfactory, but can be used to augment a presentation. This is the approach used in the O'Reilly series. For the more artistically inclined, a better approach might be to create illustrations manually and use a scanner to enter the illustrations. Scanners are quite affordable today. While somewhat more expensive, a better solution is a graphics tablet. This will allow you to enter the drawing directly into the computer. Although they require more skill to use effectively, graphic tablets can considerably reduce the amount of work required to produce an illustration. Finally, sketching directly on a computer screen is a possibility. Either with a tablet PC or with a digitizing screen attached to a computer, you can use a special stylus to enter a drawing directly into your computer. The emergence of the tablet PC and the development of digital ink promises to integrate software and hardware into a single solution.

5. Discussion

For many narrative tasks in mathematics and computer science, animation would be the obvious choice. But until creating animation becomes easier, traditional print-oriented publishing will remain the medium of choice. Unquestionably, combining images and text is desirable, a direct consequence of the modality effect and the picture superiority effect. And it would appear that integrating images and text makes the best use of each.

A cellular approach is a step in the right direction in that it produces a sequential narrative that will generally reduce cognitive load. However, cells fail to fully integrate the visual with text (or auditory) learning. Moving beyond often requires graphics skills that many of us lack, or are reticent to expose to public scrutiny. However, simple diagrams are usually within our reach.

O'Reilly gets around this hurdle by relying heavily on clip art. But there are other problems with their approach. Much of the artwork tends to be distracting. Indeed, the O'Reilly books seem to be geared for a short attention span. Also, these books take a lot of space to present even simple material. Nonetheless, their approach appears to be innovative and, largely, based on sound cognitive theory.

One need only look at the notebooks of Leonardo da Vinci to see that the full integration of text and illustrations is not a new idea. But for da Vinci, everything, whether text or illustration, was just ink on the page. This should be our ultimate standard in evaluating technology.

6. ACKNOWLEDGMENTS

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Rethinking the Slide Library: Collaborative Digital Media Repositories

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ABSTRACT

As digital media repositories become commonly established there is an increasing need to adopt a more collaborative model for sharing information between individual institutional repositories. The central objective of this paper is to provide a high level summary of some of the benefits of this collaborative model compared to the more traditional constructions of digital media repositories.

Categories and Subject Descriptors

H.3.7 [Digital Libraries]: *collection, dissemination, standards*

General Terms

Design, Human Factors, Standardization

Keywords

institutional repositories, image collections

1. INTRODUCTION

The venerable university slide library, well established as an integral component of the study of art and art history, is going digital. The 35mm slide is obsolete, supplanted by the digital image. And as goes the slide so goes slide library- or at least the existence of the slide library as a physical collection of materials. The replacement is the far more flexible digital media repository.

As digital media repositories become commonly established there is an increasing need to adopt a more collaborative model for sharing information between individual institutional repositories. The central objective of this paper is to provide a high level summary of the benefits of this collaborative model compared to the more traditional constructions of digital media repositories.

2. Collaborative Digital Media Repositories

Collaborative digital media repositories make records to held resources centrally available for harvesting and/or linking by other collections and in turn link to and/or harvest records from other collections. For the end user the exchange is transparent – although the information flows from an outside source the information can be displayed seamlessly within the context of the university's system and its own collection records.

Under this model a university's digital media repository might someday consist primarily of pointers to resources that are held in other places: faculty teaching collections at the university, image collections at other universities, and to research libraries, museums, archives, or other content aggregators.

As with interlibrary loans digital media repositories vastly increase the amount of resources available. But unlike interlibrary loans resources may be infinitely exchanged - freely, effortlessly and seamlessly.

This model of a collaborative digital media repository – relying upon the exchange of information and digital media between systems- differs significantly from the traditional model of digitization and collection that began in the mid 1990's. Implementations of digital media repositories have historically followed the model of the slide (or media) library – a deposit of tangible acquired materials, aggregated in a centralized system regardless of originating source.

With slides and other physical media this is a necessary construct - a slide can't be in two places at once. To build a usable collection slide libraries must acquire and manage duplicate materials from outside sources.

With digital media this is not a limitation – and duplication and collection regardless of origination is an inefficient means of building digital media repositories. The collection model for digital media repositories assumes many of the same disadvantages of the physical model:

→ Collection models encourage duplication of media across individual repositories.

There is upkeep required in preserving digital media. Digital storage and associated costs have fallen but the labor involved in maintaining large amounts of data can be prohibitive, particularly for small institutions.

Duplication of media and associated records across disconnected repositories is a barrier to research.

Searching disconnected repositories with overlapping collections makes it more difficult to discern the most appropriate materials for use.

→ The repository, regardless of originating source for materials, must maintain cataloging information for all materials.

The distance and disconnect from originating source increases the likelihood of inaccurate object metadata and media.

Licensed collections of digital images acquired from commercial or non-profit aggregators typically include both digital media and object metadata corresponding to the media. This information is usually transformed from information provided by the original source and may be inaccurate or out of date. There is no easy way to validate this information against an authority

Repositories typically must transform metadata for acquired materials into their own data structures as they are ingested. This is inefficient and can result in inaccuracies.

→ Collection models and disconnected repositories provide a barrier to efficient media distribution and encourage mass digitization of any available material.

If a new image is produced by a museum it may take years, or perhaps never, for this image to trickle out to individual repositories outside of the originating institution.

Unfortunately, early digitization projects often emphasized quantity over quality – for example scanning 3rd or 4th generation 35mm copy works. Predictably this has produced a glut of low quality digital media that persist in institutional repositories as representative images. Some of these images have been pulled into aggregate licensed repositories, like ArtStore, and are still distributed even when higher quality images are available from the originating institution.

This issue is of particular relevance for the study of art – where a high quality image is critical to further understanding and knowledge of the underlying work.

2.1 Benefits of the Collaborative Model

Collaborative digital media repositories show great promise in addressing many of the issues summarized above.

→ Collaborative repositories retain the relationship between owner (source) of a resource and the repository that is linking to that resource.

Users from any linked repository can trace a resource back to its source for more detailed and authoritative information about that resource.

→ Collaborative repositories lessen the institutional burden of maintaining collections by providing an efficient way to access other data sources without having to duplicate records and digital media collections.

Under the collaborative model each repository manages its own data – eliminating the need for an individual repository to maintain records and media for external resources. The repository only needs to update its own holdings – these updates are then reflected throughout the linked systems dynamically.

By emphasizing metadata standards for data sharing collaborative models reduce the amount of data transformations required.

→ For museums and other institutions that have invested heavily in proper digitization of their collections collaborative repositories provide an effective distribution channel of high quality digital media.

Collaborative digital media repositories allow a much closer relationship between the producer of the resource (such as a museum) and the consumer of that resource (a university) than has traditionally been available. This means, potentially, higher quality images and better data (object information) for academic use.

2.2 Implementation

A thorough discussion of the specific tools and systems available for implementing collaborative digital media repositories is outside of the intent of this paper. However, a number of research projects currently underway to promote and test collaborative relationships between institutional repositories should produce concrete recommendations and implementation guidelines.

One research project that I have been involved with is the Museum Collections Sharing Working Group, sponsored by OCLC. [1] This working group was formed to explore the implementation of a specific system for making museum collections accessible to trusted partners.

The Museum Sharing working group is testing the exporting of object records into CDWA Lite XML [2], These CDWA-Lite XML records will then be made available for harvesting via Open Archives Initiative - Protocol for Metadata Harvesting (OAI-PMH) [3].

The combination of CDWA Lite with OIA-PMH has potential for widespread adoption in the museum community owing to its lightweight data structure and relative ease of implementation. These are important aspects for cultural institutions - traditionally (and justifiably) wary of adopting any systems that have

elaborate data transformation requirements or that are difficult to implement.

By adopting a minimal set of required data elements CDWA Lite provides a much saner method for building shared object data records. Extracting data from complex data records into CDWA Lite, once the appropriate data crosswalks are established, should be fairly straightforward.

One objective of the working group is to produce a software application (which will be freely distributed) that will automate the mapping process from a specific collections management system that has been widely adopted by cultural institutions. The hope is to then encourage development of a more generally oriented software application that would perform these data mappings from any collections management system.

3. Conclusion

Truly collaborative digital media repositories are years away from full implementation. Nevertheless, institutions creating or updating digital media repositories should keep

in mind “sharing friendly” practices. It certainly seems inevitable, based on the overall benefits and trends in technology, that collaboration will be necessary to ensure the long-term viability of digital media repositories.

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Mediaglyphs as New Language – “cyber-HANGMAN: e-Commerce”

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ABSTRACT

This paper provides a sample of Danille M. Font, M.F.A. most recent exhibition, *Cyber-Hangman: e-Commerce* along with her current research project Mediaglyphs as New Language addresses the political economy of new media and Internet business expansion in Europe and the United States.

Categories and Subject Descriptors

A.0 [General]: Conference Proceedings – *Mediaglyphs as New Language* – “cyber-Hangman: e-Commerce” by Danille M. Font, M.F.A.

General Terms

Design, Economics, Standardization, Theory, Legal Aspects.

Keywords

My topic fall under all areas Semiotics, Semiotic Disobedience, Politics of e-Commerce, Internet Globalization, Technology Law, Technology/Business, Education, Art, Design, Advertisement, Multimedia, New Media History, and Cross-cultural Prospective.

1. INTRODUCTION

The proceedings are the records of the Visual and Computational Teaching and Learning: a conference for college educators at The College of Charleston, South Carolina on Saturday, November 17, 2007, presented by Danille M. Font, M.F.A.

Due to the advent of computers and the Internet, languages and cultures are now visually merging in ironic ways. This is illustrated in Danille M. Font's exhibition on new media advertising images, called “Cyber-HANGMAN: e-Commerce”.

The exhibition and lectures address not only the instant recognition: new marketing design techniques which are unique to

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Visual and Computational Teaching and Learning: *Mediaglyphs as New Language* – “cyber-HANGMAN: e-Commerce”, November 17, 2007, Emeryville, CA. USA., Danille M. Font, M.F.A., Copyright 2007.

new media within online, time-based and print media advertisements, along with a critique of new media tools. They also address historical and socio-cultural anthropological evaluations within media globalization that includes: a comparison of how a Social Democratic system (European) vs. Capitalist (American) system has embraced media, technology and cultural changes; unconventional economic marketing trends that document buyouts between tech companies; international copyright and trademark infringements and giving credit where credit is deserved.

Many of the images have nothing to do with the actual product they sell, but they do reflect a highly-competitive market with non traditional business strategies: a “do or die” attitude used to gain consumer attention, which became a bridge for the consumer to physically adapt to technology uses and gain curiosity towards the Internet. Each image unlocks a historical narrative of what was happening in a newly developing industry.

Danille M. Font, M.F.A., has integrated art, computer science and digital multimedia into traditional curricula at renowned undergraduate and graduate institutions in the United States, Europe and South America. Danille has made it a special interest to document the history of new media and current changes in the U.S. and abroad.

*All images in her show are ©, ™ and/or ® protected by their rightful owners. The images in this exhibition are not for sale and are used exclusively for educational purposes, but all lecture materials and/or written materials and its content has been copyright by Danille M. Font, M.F.A.

2. MEDIAGLYPHS AS NEW LANGUAGE

Traditionally, art has been bound by the physical and exists as a way to describe the natural world. Mediaglyphs, a new form of pictorial and written imagery, are based not upon the organic needs, actions and movements of people, but upon the inorganic constructs and developments of humans in response to business demands and rapid shifts in intellectual property and digital technology. Mediaglyphs are not bound by the physical world; they are limited only by the expanse of human mind.

The most obvious of the inorganic constructs is the computer, primary source for the new mediaglyph. Computers exist as structures in which the natural world is placed, rather than a development in response to nature. Their function is not to describe, but to emulate the real world; computers are unique in

that they can be multiple things simultaneously, be it a desk, filing cabinet, calculator, radio, telephone, film studio, art studio, etc. Mediaglyphs allow the creator to assign meaning to any visual cue. This in turn reinforces the written message by direct or indirect association. Due to the advent of computers and the Internet, languages and cultures are now visually merging in ironic ways. Dubbed “New Media” in the last decade of the twentieth century, mediaglyphs have become the standard in the twenty-first century. This technological revolution gains its spirit by embracing the new and the yet-to-exist, whereas traditional invention relied on older technologies and a natural evolution of use. New media strives to always be considered cutting edge and to act as a holding cell for emerging technologies and the methods by which they are described.

With a continuous seeking of the next or newest technology comes an equally demanding need for the language to describe it; i.e., language by which one can describe the next evolutionary stage of the process. Over time, this high-end emergent language filters through the traditional levels of mass culture, where pieces are absorbed into the collective consciousness. There was a point in time when the words “web” and “surfing” had no commonality in language and were nothing more than a combination of two irrelevant words. Today, they carry the weight of a generation and represent the explosive development of the Internet (or World Wide Web), the global network of linked computers that has since transformed the way people communicate and do business. Within just a few years during the Internet/Digital Gold Rush Era of the late 1990s, the hyper pace of technological development, coupled with the introduction and broad acceptance of near universal Internet access, fueled an entirely new form of communication. It is within this framework that business found ways to rapidly adapt, in order to maintain its relevance in society and its place in culture.

With the advent of this new media came a new form of business known as e-commerce. Essentially, it removed the brick and mortar structure of a traditional business and established the practice of an electronic, computer-based, virtual business. This new format demanded a new form of communication, a way to reach the target audience within the parameters of emergent technology and the new language it produced. Thus, mediaglyphs were born—images conceived, developed and rendered entirely by computer to function as virtual product and as print ads for new technology. Used to attract consumer attention, these mediaglyphs and other unconventional marketing techniques also served as a bridge for the consumer to physically adapt to new technology uses and develop an understanding of the Internet. These images were conceived, developed and rendered through entirely new means; e.g. increasingly complex mathematical equations to arrange strings of 1s and 0s, which in turn dictate representative colors, shapes and patterns on screen, that can ultimately create physical, stand alone images or even complete works of art.

Though these 1s and 0s just describe the on or off electric impulses in a microprocessor, the end result is a creation with no direct physical input outside of a human mind, other than a click of a mouse. Images are conceived, developed and completed in a strictly visual manner on a light based screen. Images are then output on a printer, thus recreating a tangible physical work in

either RGB or CMYK color simulation, or left to exist only viewable by the screen of a computer monitor. This medium was developed with the sole purpose of imitating the natural world, rather than a development in response to it. It is an artificial reality for creation and this is what separates mediaglyphs from all other art forms. Though created through the confines of an artificial medium, mediaglyphs evolved into a sophisticated, humanistic interpretation of the natural world.

Just like the cave drawings of early human civilizations, mediaglyphs have their primitive origins. These are the earliest computer developed, pixel-based symbols such as early computer “desktop” icons. Tiny squares pixels were arranged in such a way as to give the impression of a trash bin or folder. Over time, these small icons encompassed meanings far beyond their original purpose. Today, with the breakdown of boundaries between established media, such as film, photography, illustration or Fine Art and the loss of distinction between high and low art, mediaglyphs have become *lingua franca* to the fields of art and design.

3. “cyber-HANGMAN: e-Commerce”

This cyber-Hangman card of removable stickers by Stickety-Doo-Da™ exemplifies current, non-traditional advertising strategies in the highly-competitive “do or die” marketplace of e-Commerce. The card promotes an arbitrary relationship between new media (“cyber”) and the product being advertised (the children’s game “Hangman”). This graphic caricature illustrates the new breed of worker at a typical start-up technology company where the dress code is “casual”—blue jeans, dress shirt and tie. The game cyber-Hangman perhaps unwittingly conveys the tremendous pressure felt by both employer and employee to succeed in a rapidly changing industry. The image below is an actual product:

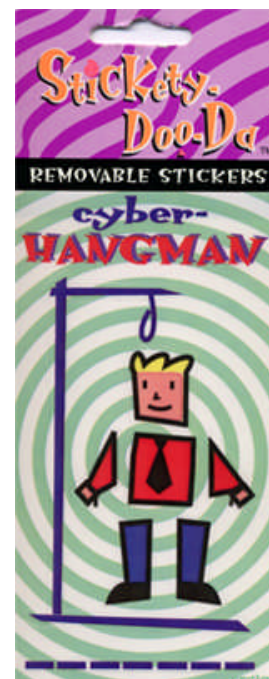


Figure 1. Stickety-Doo-Da: Removable Stickers.

I developed the exhibition “cyber-HANGMAN: e-Commerce” to demonstrate how the history of e-Commerce itself is inscribed within the graphic images arising from these new marketing strategies.

Traditional advertising has long relied on images that have something to do with the actual product being sold. What *is* new is the use of non-association of arbitrary images to direct the consumer’s curiosity to the Internet and to help the consumer physically adapt to new applications of technology. These new marketing techniques enhance company recognition in a cyber environment.

The game of Hangman begins with one player choosing a word whose letters are then guessed by another player. For each wrong guess, a new part of the stick figure of a hanging man is drawn. I encourage the guests to my exhibition to play the game of Hangman according to the rules. As players they will determine what is being sold to them *before* they read the detailed specs listed under each image. In most cases, my guest will lose (and thereby become the hanging man). And in losing, they will gain an appreciation of their role in the history of e-Commerce.

The succeeding images are examples from my show 3.1- 3.3.

3.1 “Setting the Record Straight”

The following is a short explanation of these images for lecture presentation and gallery presentation, Peoplesound and Napster:



Figure 2. Translation: We’ve got the music. Free of charge.

In setting the record straight, the first free downloadable music service to come on the market was Peoplesound based in Britain, which was conceived by a German with an MBA degree and 75 million dollars from private investments in 1998. Peoplesound allowed consumers to download MP3 music and/or customized CD mixes. It was very popular and endorsed by the European Musician Union. In a social system, as in Europe, Peoplesound created contracts with emerging artists that shared 50% of the profits and appointed established musicians’ stars to its board of directors to secure their success.

In the U.S., we heard only about Napster; while tech magazines made further claims that the Internet is an American phenomenon and reported on Napster and other U.S. clones. Their reports were full of speculation, and in many cases lacked a global perspective in regards to international companies.

In contrast, Napster was started by a college dropout who had no business model nor start-up venture capital. Within five months after Napster was launched in 1999, the Recording Industry

Association of America (RIAA) filed a lawsuit preventing Napster from continuing peer to peer file sharing of music tracts of MP3 formats because it infringed upon various copyrights. In February 2001, Napster was ordered to stop distributing copyright music until the music biz and Napster found a mutually beneficial solution in assuring copyrights and royalties.

In November 2003 Napster re-emerged and a year later, if you went to Peoplesound.com you would see small web advertisement by Napster claiming its new business identity: “Legal, Safe & Easy”.

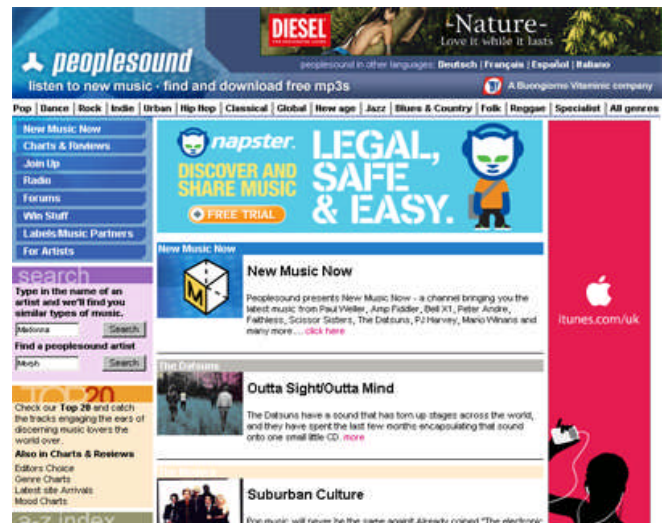


Figure 3. Peoplesound Website: with Napster claiming its new business identity: “Legal, Safe & Easy”.

Today, we see the first ever advertisements that document the evolution of a company’s dirty laundry that reads:

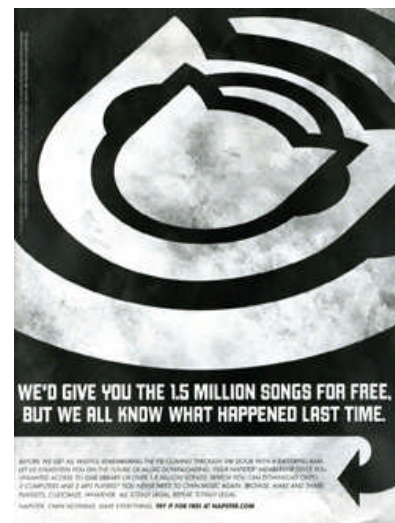


Figure 4. Napster: reincarnated and proclaiming it’s past dirty laundry.

**WE'D GIVE YOU THE 1.5 MILLION SONGS FOR FREE,
BUT WE ALL KNOW WHAT HAPPENED LAST TIME.**

BEFORE WE GET ALL WISTFUL REMEMBERING THE FBI COMING THROUGH THE DOOR WITH A BATTERING RAM, LET US ENLIGHTEN YOU ON THE FUTURE OF MUSIC DOWNLOADING. YOUR NAPSTER® MEMBERSHIP GIVES YOU UNLIMITED ACCESS TO OUR LIBRARY OF OVER 1.5 MILLION SONGS, WHICH YOU CAN DOWNLOAD ONTO 3 COMPUTERS AND 2 MP3 PLAYERS.* YOU NEVER NEED TO OWN MUSIC AGAIN. BROWSE, MAKE AND SHARE PLAYLISTS, CUSTOMIZE, WHATEVER. ALL TOTALLY LEGAL. REPEAT. TOTALLY LEGAL.

**NAPSTER. OWN NOTHING. HAVE EVERYTHING.
TRY IT FOR FREE AT NAPSTER.COM**

In small print along the side of Napster print advertisements it reads: *IT IS NECESSARY TO MAINTAIN A MEMBERSHIP IN ORDER TO CONTINUE ACCESS TO SONGS DOWNLOADED FROM NAPSTER. And for further clarification it's not for free, a membership cost of \$9.95 a month.

3.2 “Employees Were Considered Dispensable”



Figure 5. Internet Job Boards: Thingamajob.com
Other websites post your resume.
We put it into the right hands.

Thingamajob® print advertisement exemplifies the Gold Rush of new technology their opportunities and the fallacies' but, at the same time being honest to the consumer. Thingamajig: something whose name is either forgotten or not known.

During the “Gold Rush of Technology, 1998-2001,” buyout and layoff tactics were being exploited in Silicon Valley that had

adverse effects on both employees and consumers. During the height of trading on the NASDAQ stock exchange, U.S. employees were considered dispensable and layoffs created a new opportunity to boost quarterly stock prices. This artificial funding could prop up a failing company temporarily or allow profitable companies to better their profits temporarily by cutting costs. In large part, what drove this boom era for both the computer industry and the stock market was speculation based on high growth potential. The peak of the Technology boom era exemplifies the cut throat competition and roller coaster rides that many companies and their employees underwent.

How could this happen? Due to the speed of technology development, most computer start-ups had a life span of 3 to 5 years and faced tremendous pressure to succeed: a company typically had to make it big within three years. The objective of many startups was to ultimately place themselves in a neglected niche of a larger corporation such as Sun, Cisco, or Microsoft, by making a product that the industry founds useful and ultimately could not do without. The start-up company marketed its product/services to both the giant and its affiliates and if fate smiled on the start-up, it either went public or was bought out by a larger company or in some cases both. If after three years the company showed no profitable gain, they often petitioned to file bankruptcy.

The hyper growth of a start-up company such as AltaVista (an Internet search engine) that began with 55 employees and grew to more than 500 in less than six months is also often cited as examples of an aggressive start-up. Of course, now that the boom period is over, people are correctly emphasizing that while a few companies made it big, the majority failed and they failed for the very reasons that most traditional businesses fail.

3.3 “Emerging Technologies and their Impact: Is it CyQuest or SyQuest?”

The first image, a print media from a German company CyQuest (www.cyquest.de) depicts a relaxed alien drinking a cocktail while computer code 1 and 0 floats above his head. The slogan is “*Erst das Vergnügen, dann die Arbeit!*” and translates as “First joy then work!” The second image, an American company SyQuest, Technology, Inc., depicts a 200MB SyQuest cartridge with the slogan “FILL ‘ER UP.”



Figure 6. “Is it CyQuest or SyQuest?”

Both images market the comfort and ease provided by their products. This is reinforced by the small font slogans appearing

below each ad. The German CyQuest slogan reads “*Das Erfolg-Reich-Spiel*” which translates “The Successful Play.” The U.S. SyQuest logo reads “The World Standard.” Both images are celebrating the ease with which technology creates a feeling of security.

The story behind these images is fascinating. Many European e-commerce companies are riding the wave of current or previously successful U.S. e-commerce companies by legally adopting their name. In this case, the German CyQuest, an online scavenger hunt game and Internet merchant site, knowingly adopted the identity of SyQuest Technology, Inc., a former U.S. Company that produced exterior and interior hard drive storage devices.

CyQuest achieved this by changing only the first letter of their logo identity name and using the same font to create a similar logo identity. They added a reversed U.S. dollar sign to their logo, which in most cases has caused confusion within the e-commerce market place. Even though CyQuest sold a completely different product, this confusion aided the German company in achieving successful product recognition by association with the original American SyQuest who for many years dominated the market-place in removable computer storage devices for personal computers.

CyQuest sells information management through the Internet and is modeled after U.S. Internet search engines. CyQuest builds an information bridge between the enterprise and the consumer in the form of a scavenger hunt where the consumer can win, for example, a dream job by breaking through the social system of class structure associated with his current placement in the job market and rise to a higher level. The consumer gives CyQuest the information about items he or she wants to buy and CyQuest goes out and finds the cheapest price. CyQuest got away with this blatant infringement because even within international copyright agreement treaties, there are loop-holes that vary from country to country that allow for exploitation for profit under the law.

What I find very interesting is that the Germany Democratic Social System law denounces product competition within advertisements but this is not consistently applied to the world market and therefore a German company can appropriate a U.S. company’s identity. In the German market, you would never see the commercial slogan “Take the Pepsi Challenge,” where Pepsi asks the consumer, who is captured on hidden camera, to compare what tastes better, Coke Cola or Pepsi. This type of advertising was illegal in Germany until 2000, but highly popular in the U.S. market which thrives on such competition. The Internet sparked new changes on how to do traditional business in Germany.

SyQuest Technology, Inc., based in Fremont, CA., heart of Silicon Valley, dominated the market for 14 years by owning 100 percent of the removable (storage drive) markets. SyQuest, supplied the consumer with the first hard disk exterior drive, similar to the hard drive on most personal computers but with superior transfer rate for time-base multimedia. In 1998, SyQuest was bought out by Iomega Corporation who supplied the market with an inferior product made out of plastic – a glorified floppy – that contained less storage space and delivered a slower transfer rate. Iomega marketed their Zip cartridges and drives for multimedia uses by misinforming the consumer. Iomega did this

by marketing to the novice multimedia user newly entering the market who did not understand the demands placed by time-based multimedia and who was unfamiliar with floppy design. In several cases, the Iomega Zip plastic platters would warp due to over-heating when Zip drives were bundled within computer systems.

In November, 1998, Iomega purchased SyQuest’s intellectual property and other assets for U.S. \$9.5 million in cash, pushing a long standing giant out of the market. The buyout also put an end to an outstanding patent and trademark infringement lawsuit that both companies were fighting, an excellent example of Iomega’s going around the back door to buy an answer to its problem. An even sadder story, SyQuest lost so many sales that it was forced to lay-off 950 employees, half of its workforce in a last-ditch restructuring attempt to slash expenses. The effort failed and when SyQuest ultimately filed Chapter 11 bankruptcy, Iomega picked them up at a rock-bottom price on April 22, 1999.

During the sales agreement, SyQuest agreed to change its name from SyQuest to “SYQT, Inc., while Iomega agreed to providing customer support for maintaining (or repairing) their original products. Shortly after the agreed buyout, Iomega sold off only their legal obligation to continue to service SyQuest warranty repairs but, Iomega did hold onto SyQuest’s inventory, physical assets, patents and other intellectual property to prevent competition in the market place. Iomega frozen SyQuest’s superior inventory and sold their own inferior product to the consumer. This happened at a time when consumers were not fully experienced with the transfer-rate demands of time-based media in low-end storage devices. These marketing tactics are not foreign to the computer technology industry: countless companies suppress superior technology to their consumers.

4. CONCLUSION

If interested in hosting a show and/or guest lecture please contact Danille M. Font, M.F.A. at danille@gmx.net.

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Tied Up in Knots: Spatial Reasoning for Visual Literacy using 3-D Dynamic Modeling Software

Ellen F. Campbell, Ed.D.

Abstract:

Visual literacy, the spatial language of syntax and organization, can be used to fully explore concepts by using 3-D dynamic modeling software. Concepts as diverse as the Civil War and a children's classic book, *Fantastic Mr. Fox*, by Roald Dahl can be animated by all ages from pre-schoolers to college students as a sequence of topological actions. These still frames or digital stories can demonstrate more complete comprehension of the complex spatial concepts and can be accurately assessed. This paper is of the theoretical transition from hard-copy assessments, essays, and tests of students' knowledge to a dynamic computer model or animation as a visual demonstration of what students understand, comprehend, and know. By defining visual literacy as a recognized standard of literacy of non-print material, this paper and presentation examines the tasks and criteria to use in any classroom with any age student. There is a need is to have teachers and professors comfortable using software to illustrate, display, manipulate, move, and record 2-dimensional and 3-dimensional concepts over the duration of time and when some events occur simultaneously.

Using assessment tools that measure diverse content areas, the paper presents multiple methods to gain a greater range of evidence of knowledge and comprehension, application, analysis, synthesis, and evaluation as Benjamin Bloom defines the hierarchy. As an additional measurement tool of knowledge, dynamic software opens avenues to address diverse learners within a classroom.

Visual Literacy and Spatial Reasoning

Visual literacy shares in the development of a student's understanding of language but often overlooked as an essential tool for students to grasp symbol systems and understand relationships and patterns. Syntax, semantics, and pragmatics are the foundation of all symbolic language. Visual literacy is a language of icons, signs, pictures and art that is 'read' as any other symbol system with specific rules, common meanings and uses.

Spatial reasoning is an internal organization of objects and events held by the mind, turned, twisted and bend to conform to 2-dimensional and 3-dimensional space. Using dynamic software that is user-friendly, accessible, relatively inexpensive for schools and universities, students can demonstrate knowledge that multi-dimensional by producing a product that shares the interpretation of complex concepts. Previously teachers and professors were only able to be represented knowledge as static print, illustrations, drawing, and diagrams that could not show movement over time unless reenacted and video taped, an awkward time consuming process. By using dynamic software, students are able to work independently or in groups to experiment and practice developing concepts while creating a permanent record of attempts and records of a final product.

Exploring concepts and activities that move and shift over time are difficult to see and handle in the classroom. When studying the Civil War, battles and movement of troops are often revealed in print or video when it is the individual student juxtaposing the generals and troops in proximity and moving them over a time line that allows students to interact and record their understanding of the results of the battles. It might be

considered similar to moving plastic men on a game board but in dynamic software, students can record their movement of the men and generals that presents evidence of comprehension in a reasonable period of time within a classroom when compared to a paper-and-pencil test. Visualized concepts can be translated from text where dexterity with words was the sole determining factor in assessing a student's understanding of a complex multi-dimensional concept. By adding this method to the assessment tool box, teachers and professors are able to better assess the understanding of a diverse group of students in the class. The assessment of a dynamic software presentation is as valid as a paper-and-pencil test when teachers and professors are able to use the common criteria. It is no more subjective than an essay or report when students select words, syntax, and semantics.

The expectation is that students can learn the common language symbol system and utilize it to share meaning and semantics and teachers and professors will be informed recipients of these products as evidence of knowledge shown from dynamic modes of communication.

The Levels of Development of a Common Language

Marks on a paper named by a child represent an object, his or her first symbol. A society names common symbols to represent objects, groups of objects, events, feelings, and ideas. As the child's develops and marks her scribbles as "cat" or learns that three other squiggly lines on a paper that resemble, C-A-T, also represent the same object that purrs, moves, is furry, and has whiskers. She has classified 'catness' as a symbol for all cats.

How the child differentiates between that classification of “cat” and a similar classification of “dog” are part of the child’s topological map and is necessary for literacy development. Topological mapping is the mind's method of visualizing the connection of objects and events and translating these into symbols such as icons or language. A young child develops this incipient ability around the age of two years. Educators who enhance that developmental stage provide an enriched environment to expand the topological mapping of the mind. The child's topological map helps him name objects, classify attributes of the objects, and form a personal symbol system. Teachers and professors broaden the range of symbols for a child to examine.

James Gleick in his book, *Chaos: Making a New Science* in 1987 writes about topology as the visualization of shapes and their relationships: “Linking topology and dynamical systems is the possibility of using a shape to help visualize the whole range of behaviors of a system. . . Shapes that look roughly the same give roughly the same kinds of behavior. If you can visualize the shape, you can understand the system” (Gleick, 1987, p. 47).

Understanding visual literacy by constructing a mental topological map is a child’s way of knowing the shared syntax of symbol systems. The rules of ordering visual information, positioning and sequencing of forms, identifying the shape and size of the objects in time and space are the elements of the mind that assist the child to know the world. The rules for artistic composition and written composition vary, but both domains have rules. The syntax differs and is unique in each domain, but for a child learning symbol systems, at approximately age two, the learning process is the same. The center of interest of a painting is similar to the plot of a story, the phrase says it all, the center.

A center is a topological location, a place, a position, a visual designation. A symbol is a symbol no matter what the domain.

The syntactical understanding for a child is what remains constant while other things change which is the same definition of topology, a mathematical concept. It is also how children classify objects. When a child sees multiple pictures of a cat and then sees a cat from a different perspective, the child will know that it still is a CAT because of what remains the same while other things change. Topological understanding is how a baby first learns spatial relationships. His mother's face remains the same while other aspects of her appearance change, the eyes are always above the nose and the nose is always above the mouth, no matter if the mother smiles, frowns, or turning away. The essential features are the constant elements that allow a baby to name and classify the face. This same topological mapping is how a young child understands symbol systems. What remains the same about a C and c or \mathfrak{C} or \mathbf{C} , and what changes defines a symbol for a child.

The semantics of a symbol system are the meanings attributed by the child or by society. A symbol of a cat, either a picture or a cluster of letters, derives its meaning from the cultures. Its meaning in ancient Egypt is different from its meaning in ancient Asia, and differs for a young child in the United States today.

Pragmatics, the uses of a symbol system in language development, can be culturally based. As a child collects new information about the world, and learns how icons and symbols represent the information provided by all of the possible sources, he must learn its traditional uses.

As students develop mentally, emotionally, and physically, they internalize the visual icons that represent objects, events, and emotions. Visual literacy overlaps in its development with literacy and numeracy. Perhaps for the first time, it became widely recognized that disciplines exhibited their own rules and principles and that these might be attributed, in some concrete way, to structures and mechanisms in the brain (Gardner).

Brain researchers such as Sprenger have examined how information is processed: “The left hemisphere is able to analyze; it deals with parts. The right hemisphere deals with wholes. The left hemisphere attends to spoken language, and the right hemisphere attends to body language. Analyzing music would occur in the left hemisphere and enjoying it in the right. The left hemisphere is sequential and time oriented, and the right is more spatial and lacks the time component” (Sprenger, 1999, p. 42).

The Assessment of Visual Literacy as a Tool in Every Discipline for All Ages of Student

The elements of a good visual presentation are similar to the elements of a good essay or story, play or report. Below is an assessment holistic checksheet for teachers and professors to use for defining elements of visual literacy.

Assessment of Visual Literacy Comprehension

“... artistic activity is a form of *reasoning*, in which *perceiving* and *thinking* are indivisibly intertwined.” Rudolf Arnheim, *Visual Thinking*.

By the end of the unit of study, the successful student will be able to view, evaluate, and illustrate complex concepts using visual language by being able to:

1. *EXPLAIN*

- * Describe the content of the visual image.
- * Explain complex insights with credible reasons demonstrating knowledge of ideas.
- * Make fine, subtle distinctions; aptly qualify opinions.
- * Predict understanding.
- * Avoid superficial or overly simplistic views as the only explanation.
- * Reveal a personal, thoughtful, coherent grasp of the subject being visually developed.

2. *INTERPRET*

- * Interpret, translate, and narrate effectively the significance of the visual image.

- * Use language to translate the meaning of the images, even read between the lines.
- * Offer plausible accounts of many of the possible purposes for the non-print text.
- * Offer a meaningful and illuminating account of the complex relationships.

3. *APPLY*

- * Appreciate and tolerate diverse perspectives and view points.
- * Critique and justify a position to see the image from the perspective of the creator.
 - Identify the **FOCAL POINT** or **CENTER OF INTEREST**.
Does the image have a dominate spot the eye notices first? It can be small as a dot that could be red in a sea of gray or it could be large like a pale blue hat that fills almost the entire frame. It is the central theme.
 - Notice the variation of **SPACE** used with background and foreground space.
Are the forms in the image in a visually intriguing arrangement with the **POSITIVE SPACE** designed against the background, **NEGATIVE SPACE** in an intriguing positioned with variation and subtle changes.
 - Read the **BALANCING POINTS** that support the focal point.
Do the less important forms in the image help the viewer read the image? Do they offer support? Often balancing points are in groups of three because it forms a visual triangle causing less direct tension as with only two elements that would fight for attention.
 - Locate the **TENSION POINT(S)**.
Does the image have at least one spot where the eye senses suspense, uncertainty, quandary, intrigue, or mystery? What will happen next?
 - Feel the **COLORS** impact on the image.
Does the color palette project a feeling? Is there balance between the colors chosen or do the colors overpower the forms? Is there variety with the colors selected and do they enhance the visual story?
 - Assess the **IMPACT** of the visual.
Does the image make the viewer want to study it further or revisit it later? Does the image have visual power?
 - Account for the **SCALE, PROPORTION, and PERSPECTIVE** of the image.
Are the elements in the image in a scale that creates interest rather than clutter?
 - Follow the **DIRECTIONAL LINES** or **FLOW** of the elements in an image.
Does the eye move from one element in the image to another? Some aspect focus the eye in another direction so the viewer sees all, like an arrow would direct the eye.

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The Conclusion

Visual Literacy embeds an understanding of spatial reasoning and the disciplines expand both the syntax and semantics in the content. Visual literacy must exhibit a common language in order to create a shared form of spatial communication. By developing a student's ability to reason about spatial relationships, an educator builds his spatial topological map. This topological map is the mental construct used by students to

build a symbol system about the world. Spatial intelligence is a visual way of understanding and interpreting the world, creating images, judging distances, changing elements, visualizing concepts and sharing knowledge and ideas with others.

Culture requires a shared symbol system with common language. By being invited into the visual world of complex concepts in every discipline, a student will have a larger shared visual vocabulary of the world, a richer symbol system and an expanded symbolic language to explore and record spatial relationships and patterns.

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Building Collaborative Learning in the Arts and Sciences

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ABSTRACT

The construction of teaching models and interdisciplinary programs for learning and research in collaboration between technology, arts, and sciences poses challenges for smaller liberal arts institutions. There is the common challenge of bringing technology and electronic media into a traditional arts practice, and the reverse challenge for those in science and technology in learning to support and inform digital artists. Additionally there is the challenge of developing teaching models to effectively equip students to work in the emerging world of digital media. At smaller schools there are also issues of time for research, space for lab or studio work, and limited enrollments.

We describe an approach to developing such an interdisciplinary program at our institution. The goal is to establish a cross-curricular concentration uniting common interests in Art, Computer Science, Music, and Physics; students majoring in one department would take specific courses in one or more of the others before pursuing a directed interdisciplinary project. Our initial approach has been exploratory and targets three levels of learning. We report on a first attempt to introduce a digital media project in an introductory computer science class, a newly-developed course in multimedia programming and design, and a project to develop expertise in programming and design systems for creating digital media in the context of an independent study/research project in the arts.

1. INTRODUCTION

Beginning in 2005, four Sewanee faculty members in fine arts, science, and technology began to discuss models for interdisciplinary research and instruction, as part of an initiative we called TASC: Technology, Arts, and Sciences in Collaboration. While we began this exploration with very diverse aims, it soon became clear that our ultimate goals would be the development of a curricular initiative for students interested in digital media and a laboratory to support instruction and research in these areas. Achieving these

goals will be challenging; as some of our colleagues have no doubt experienced elsewhere, we struggle with issues of time, institutional support, and low enrollments in specialist courses.

In light of these challenges, we have begun an exploratory approach that we hope will be the seeds for growing an interdisciplinary curriculum in digital arts and multimedia computation. This paper describes the motivations for our work and the early stages of our efforts to promote interest in digital media as a tool and research medium. It further outlines courses and content designed to prepare students for independent study and research in collaborations spanning two or more of the TASC content areas. Finally it outlines future course development and areas of collaboration, focusing on interaction between the Art and Computer Science programs.

2. MOTIVATIONS

In our initial conversations about TASC, we discovered areas of common ground and needs that we did not know existed. Some of the motivations for pursuing this collaboration included the following:

- Digital artists are finding that many of the proprietary software tools they use impose limitations that could be overcome if the tools were extensible. Such extensibility often requires programming skills.
- Faculty in the arts are increasingly teaching rudimentary programming skills to their students for developing digital media using content authoring tools such as Flash [2].
- Computer scientists have begun incorporating multimedia computation in the introductory courses as a way to motivate student interest.
- Open-source and collaborative technologies provide viable and affordable options for departments wanting to incorporate digital media in their programs.

From the fine arts perspective, one of the biggest hurdles to using new technologies is that they are (at first) quite foreign to traditional art practice. It is easy to understand, for example, the direct relationship that the sculptor's actions have with respect to a material like stone. With electronic

media this relationship can be difficult to grasp as it involves abstraction: an action may require developing a program text, which must then be processed by the computer before execution finally shows the (possibly unintended) result. The language in which the program text is developed presents its own learning curve. These factors make it difficult to engage the material creatively in practical ways. Once the learning curve is overcome, however, it is possible for the user to work effectively and create dynamic and engaging art.

Computing allows for a dynamic compositional structure for artistic expression that can either mimic natural patterns or generate totally new structures that allow temporal changes in a given work that are not repetitive but can maintain the artist's aesthetic goals throughout. This gives artists the opportunity to explore more complex works without losing control over formal aspects of the work.

The canned, preprogrammed effects in software aimed at visual art and music can be very helpful but can also limit the possibilities for artistic exploration and discovery. Programming can expand the possibilities for artists. Teaching programming languages such as Processing [11] or ActionScript[1] enables students to explore these possibilities for themselves. The challenge, again, is that this requires another formidable layer of technical skill to achieve.

From the science and technology perspective, a lack of familiarity with the practice, theory, and critical tradition in the arts can hamper our understanding of how to best support and inform our colleagues about the impact of digital technologies on artistic research and education. There is also an unfortunate tendency to resist learning about the technologies that artists have become comfortable with, or worse, dismissing technologies as not having been built on sound, CS-approved principles.

Our approach to developing common ground, building interest in the student body and wider community, and supporting each other in overcoming technological learning curves has been, admittedly, rather *ad hoc*, but as these efforts have gained traction, we have begun to work in more systematic ways. The next section describes the initiatives we have undertaken, both curricular and otherwise, to generate an environment for collaboration.

3. COLLABORATIVE INITIATIVES

Currently, the Art department offers at least one course in Digital Art each year [3]. Students taking this course learn ActionScript for creating Flash presentations on web pages, and also work with microcontrollers and sensors, controlling them with ActionScript extensions.

Dr. Ben Szapiro of the Physics department developed and taught a First Year Program course entitled "The Science of Sound" in 2004. Students were required to design and build a musical instrument based on the principles learned in lecture. This course was offered twice as part of the ever-changing FYP initiative at Sewanee.

Dr. James Carlson organized a multimedia event in which Studio Art majors David Hellams and Kevin McCoy pre-

sented a video they created from digital reproductions of 34 prints by Georges Rouault, part of his *Miserere Series* which is owned by the university's permanent art collection. Carlson composed and performed (with Katie Lehman, violinist) an electro-acoustic score which served as a "soundtrack" to the video. The event was presented live in the University Art Gallery in November 2006.

Physics students in Dr. Randolph Peterson's digital electronics courses have collaborated with art faculty to develop circuits for use in art installations. Assignments were developed jointly between the two departments. Physics students are invited to enroll in upper division sculpture courses to collaborate with sculpture students, and Art students are invited to enroll in electronics courses.

These individual and departmental initiatives have served as motivation for developing classes designed specifically to support and build on what currently exists to eventually bring a digital media concentration to fruition.

3.1 Multimedia Programming

A new course, Computer Science 276 - Multimedia Programming and Design, was proposed in late 2006 and offered for the first time in the fall of 2007. Our aim in proposing the course was to provide a step between the introductory programming course and upper-level work (whether formal course work or independent study) in electronic media for fine arts majors, as well as another course option for students wishing to minor in Computer Science.

The basic course structure and some content is adapted from courses developed by Mark Guzdial and Barbara Ericson at Georgia Tech [6]. Primarily aimed at students not intending to major in computer science, these courses motivate programming by showing how to manipulate digital images, audio, and video. The courses were developed in response to Georgia Tech's computing initiative, which requires that all students be "computationally literate." The multimedia approach has been disseminated in multiple workshops, gatherings at conferences on computer science education, and two textbooks [4, 5].

The idea is for students to learn the basic algorithms underlying common digital media manipulations such as might be used in mainstream software packages such as Photoshop or CoolEdit. Students learn to process digital images at the pixel level, using photos from their own digital cameras or websites. They then learn operations on digital audio and the use of MIDI, the Musical Instrument Digital Interface [8], to control internal programs or external devices. Lastly they work with digital video. One consequence of this approach is that students can relate the programming they do more directly to the outcomes produced by their program.

While the Georgia Tech material is aimed at students who may have never programmed a computer before, our course requires an introductory programming course as a prerequisite, so that the students already have an understanding of the Java programming language [7]. This allows us to work through the algorithmic material quickly using a text-based language, so that we can then explore alternative ways to de-

sign and develop digital media, such as by using a graphical programming environment.

In this course we use a system developed specifically for the digital arts called Processing [11]. This system includes a customized integrated development environment, a simplified variant of the Java programming language made up of three “language levels” for learning the language in steps, and a library of functions tailored to digital art, animation, and image processing.¹ Processing provides a traditional, text-based environment for exploring digital media creation and manipulation. After working in Processing for most of the semester the students move to the graphical programming environment Pure Data [9], a real-time environment for audio, video, and graphical processing. Both Processing and Pure Data are open-source programming projects which rely on the Internet for communication with community and contributors.

Pure Data is a graphical environment in which functional units for generating and manipulating media are represented as simple icons. Connections between objects represent the flow of data through the units; the resulting network is called a *patch*. It is interesting to have the students compare their text-based programs to a Pure Data patch which performs a (more or less) equivalent operation. The patch allows them to better visualize what is happening in ways that the syntax of the programming language sometimes obscures.

The idea to use Pure Data and Processing was a natural outgrowth of conversations between the authors. Pure Data is the successor project to Max/MSP, which was first developed in 1984 and continues to be supported and taught in electronic music courses. Processing is much newer, and has also developed a loyal user community and maturity as a platform. Both platforms have been used by students and faculty working on projects in the art department.

All the same, it was not clear that Processing would be an appropriate platform for the course, so at the beginning of the summer a student was employed to try implementing various algorithms from Guzdial and Ericson’s text using the system. In this student’s words: “In most cases, it’s almost a direct correspondence between the book’s examples and the Processing code. In many cases, it’s even easier in Processing.” Our experience with the students in the course bears this out.

3.2 Further Development

Professor Carl is currently presenting a seminar on Computer Music for the Department of Mathematics and Computer Science. The seminar uses Pure Data to illustrate the theory behind electronic music generation and manipulation. The Art and Computer Science departments sponsored a campus visit by the designer of Pure Data, Miller Puckette, in order to support the seminar, promote use of Pure Data in the fine arts, and to promote interest in a local user’s group. Dr. Puckette gave a workshop on using the system and a talk about its potential and challenges. The

¹Processing also provides a mechanism for adding new libraries contributed by the open-source community, which now includes support for audio, MIDI, robotics, and hooks into Google APIs.

workshop attracted faculty and practitioners from outside the Sewanee community, including Nashville and Atlanta.

Professor Pond started the Pure Data users group with interested students. This group will meet regularly to help develop a community of student users on campus and surrounding areas. Already students from the workshop have begun using Pure Data in other art courses. The discussions surrounding Pure Data involved several disciplines outside the four involved in this project.

Professor Pond has also scheduled two simultaneous exhibitions for the beginning of the academic year 2008-2009 that involve these technologies. One such exhibition has been developed on campus and the other is from outside artists. The University Art Gallery and the Nabit Gallery are now incorporating programming media exhibitions for its shows. Casey Reas, one of the developers of Processing, opens an exhibition in November 2007.

We also intend to continue proposing courses which build on the work so far. Pond has expressed an interest in developing classes that combine acoustics, sculpture, and physical computing. Sensors and microcontrollers have become important in developing interactive art installations; two projects related to Processing support the development of software for microcontrollers using a similar high-level language. Reas and Fry point out that “the skills learned through using Processing can easily be transferred into these areas through Mobile Processing, Wiring, and Arduino.” [10]. These related projects target development for mobile phones, microcontrollers, and physical computer interfaces, respectively. Students working in this area will need a dexterity with the development tools that Art 231 and Computer Science 276 can provide.

An advanced multimedia programming course is contemplated. This course would primarily explore interactivity, with components of computer vision, machine listening, and alternative input devices beyond the mouse and keyboard [12]. Processing and Pure Data would continue to be the base platforms for this course, with the possibility of dropping into Java or C/C++ if necessary to extend the base platforms or class libraries. The requirements of this course go beyond the equipment we have in current computer labs, arguing further for a separate multimedia lab.

Our interests in sound, space, and acoustics suggest developing a Physics course that extends the existing Science of Sound course. The current structure of the Music curriculum makes adding a course specific to integrating technology less likely, though there has been at least one course that made use of MIDI. However, plans are in place to work with Professor Carlson in Summer 2008 to develop a musical piece using Pure Data.

3.3 Collaborative Independent Projects

The pedagogy of programming – the manner in which one develops relationships, actions, and events through data – can provide compelling models for the structuring of artistic content. Further, we have two models of developing multimedia, textually and graphically, each implying a separate structural model. Having given students a foundation

in these programming and multimedia techniques, we seek to develop them further both within disciplines and across them.

We believe that the most valuable experience our students will get is through collaborative independent studies. The model that has been proposed in our discussions is of a group of students from different major fields working together to realize a substantial project involving the arts and technology, alternatively meeting with their primary advisor in their major field, then with the group consisting of students and advisors from each field.

4. CONCLUSIONS

There are few disciplines that have not been impacted by technology and many practitioners have become quite adept at using computing power to solve problems in their area. However, they still may run up against the limitations of the applications they use, the usability (or lack thereof) of the resources available to them, and sometimes the limitations in computational power of the available resources. At the same time, computer scientists and developers do not always understand how computing is used in other disciplines, and are therefore unable to properly support their colleagues who are using computation to solve their problems.

Most often, students and faculty in other disciplines will need our expertise, in the form of collaboration, than they will need our courses.

The collaborative models that we proposed for the TASC project provides the faculty an opportunity to share research, support one another, and understand the ways each discipline engages these technologies on pedagogical and philosophical levels. This ultimately bolsters the liberal arts mission of the school – uniting disciplines into a program that functions much like a linked liberal studies program in the humanities. Students involved in such courses therefore will understand their work in a broader context.

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