

Patterns of Free-form Curation: Visual Thinking with Web Content

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ABSTRACT

Web curation involves choosing, organizing, and commenting on content. Popular web curation apps—e.g., Facebook, Twitter, and Pinterest—provide linear feeds that show people the latest content, but provide little support for articulating relationships among content elements. The new medium of *free-form web curation* enables multimedia elements to be spontaneously gathered from the web, written about, sketched amidst, manipulated, and visually assembled in a continuous space. Through free-form web curation, content is collected, interpreted, and arranged, creating context.

We conducted a field study of 1581 students in 6 courses, spanning diverse fields. We derive patterns of free-form curation through a visual grounded theory analysis of the resulting dataset of 4426 curations. From the observed range of invocations of the patterns in the performance of ideation tasks, we conclude that free-form is valuable as a new medium of web curation in how it supports creative visual thinking.

Keywords

curation; visual thinking; design; web media; education; pattern language

1. INTRODUCTION

Each day, on social media, hundreds of millions of people engage in *web curation*—they choose, comment on, and organize content. A limitation is that popular apps—e.g., Facebook, Twitter, and Pinterest—constrain organization of curated content to feeds and boards, using ranking algorithms based on parameters such as recency and popularity. Linear feeds are great for showing people the latest content, but provide limited support for free-form visual thinking that articulates relationships among content elements. Visual patterns, blends and combinations that express relationships are significant generative mechanisms of creative cognition [18].

We define curation in a broader cultural context by drawing from the arts *Curation* is the creative conceptualization and organization of an exhibition [36]. Works are collected, interpreted, and arranged, creating context, giving form to visual thinking, and producing cultural meaning.

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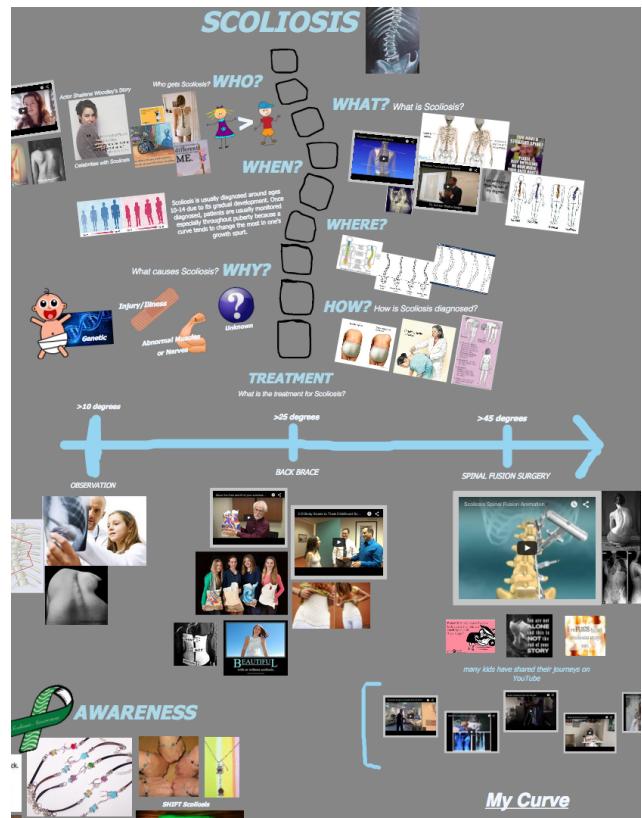


Figure 1: In *Scoliosis*, a personal health informatics free-form web curation, Katharine Kimmel manifests visual thinking by assembling her own sketches and writing with images from the web and YouTube videos [<https://ideamache.ecologylab.net/v/bM6IaLoVvt/>]. As a whole, the curation is educational and hopeful, conveying a sense of complexity and connectedness in dealing with a great challenge. *curation_patterns* = {morphology|concrete, morphology|abstract, group|spatial}

We integrate trends in art and social media to create the new medium of free-form web curation. We draw from *free-form thinking*, a creative cognitive process of open exploration, association, improvisation, synthesis, emergence, and ideation [31]. *Free-form web curation* enables multimedia elements to be spontaneously gathered from the web, written about, sketched amidst, manipulated, and visually assembled in a continuous space (see example, Figure 1). The visual assemblage forms a digital abstract map, liberated from the confines of particular websites by a zoomable user interface. The goal of this holistic medium is to support creative cognition [18] of relationships and the emergence of new ideas.

Product Innovation



Figure 2: Jordan Jump curated *Laundry Notifier* [<https://ideamache.ecologylab.net/v/teGYF8lb5/>] in the ideation stage of designing an innovative product. Elements—a conceptual statement, potential devices and companies to partner with, and patents of prior products—are spatially organized over a washing machine. *curation_patterns = {overlap|compose, group|spatial, group|nested}*

Our research question is: how does free-form curation support visual thinking with web content? *Visual thinking* is a creative process—understood by connecting the fields of art and psychology—in which perception becomes integrated with higher order cognitive operations, such as exploration, analysis, synthesis, and abstraction. In visual thinking, “Concepts take shape” [2].

We conducted a field study of 1581 students in 10 course offerings, in a variety of subjects. We formed a dataset of 4426 free-form web curations. Students used the *IdeaMâché* web app to perform free-form curation [<https://ideamache.ecologylab.net>] on ideation assignments addressing diverse intellectual activities: personal health informatics (Figure 1), entrepreneurial innovation (Figure 2), research paper inception (Figure 3), architectural design (Figures 4, 5), and lecture presentation (Figures 6, 7).

The study participants were everyday students, not professional designers or curators. Prominent creativity researchers recognize that people achieve significant ideation across a spectrum of levels of impact: mini-c (personal learning), little-c (involving friends or classmates), Pro-C (professional), and Big-C (societal innovation) [24]. The curations in the dataset are mostly mini-c to little-c. This is appropriate because our objective is to investigate how free-form web curation functions as a medium for creative visual thinking by everyday students, in diverse fields. The range of curation forms we discover has implications for the potential engagement in visual thinking by millions of users of popular web curation apps.

Through a visual grounded theory analysis of the dataset, we

derive patterns of free-form web curation: 1) *morphology* (concrete, abstract), 2) *overlap* (compose, composite, map), 3) *group* (spatial, nested), and 4) *path* (linear, non-linear).

A *pattern language* is a set of forms of spatial organization, each of which supports particular human activity [1]. A pattern language is generative. Patterns—like words, phrases, grammars, and other forms of written language—can be combined in an infinity of emergent systems of unforeseen relationships. We use the pattern language to demonstrate how free-form curation supports creative visual thinking. From our investigation, we derive implications for the design of web curation apps.

2. SENSITIZING CONCEPTS

We derive and connect sensitizing concepts from research in visual thinking, visual grounded theory, pattern languages, hypertext, information composition, found objects, assemblage, and curation.

2.1 Visual Thinking

Psychologist and art theorist, Rudolf Arnheim, introduced the term *visual thinking*, finding that perception, recognition, and reflection become intertwined in creative acts of forming and illustrating new meanings [2]. Psychologist Barbara Tversky provides empirical evidence of the abstract and concrete functions of forms of visual thinking, such as lines, arrows, maps and diagrams [45]. An ACM CHI workshop addressed how visual thinking and curation are es-

Figure 3: Christine Lee’s final paper ideation, *Feminist Hashtag Activism* [<https://ideamache.ecologylab.net/v/NcH3CXW73n/>], conceptualizes Twitter as a site of feminist activism. *curation_patterns = {morphology|concrete, overlap|compose, group|spatial, group|nested}*

sential to human-computer interaction [7]. The present research supports visual thinking through curation, as a means of knowledge creation and ideation, using web multimedia content. *Pictorial*, a recent ACM publication format (non-interactive), uses images as primary material for creating and articulating knowledge about interactivity [8]. The present research uses visual data as the primary material for creating knowledge with grounded theory methods.

2.2 Visual Grounded Theory

Charmaz articulates an iterative empirical qualitative methodology for constructing grounded theory, involving: gathering rich data, initial coding, theoretical sampling, focused coding, categorization, the incorporation of sensitizing concepts, and conceptual refinement [13]. Much grounded theory uses field notes and transcriptions of interviews as the primary form of rich data [14, 13]. Konecki advances *visual grounded theory*, shifting the primary source of empirical material from textual to visual data, as motivated by a context of research [27].

To investigate visual thinking, we treat the collected free-form web curations as visual data. We invoke visual qualitative methods [3], following other researchers who use visual evidence as a primary form of data [21]. Studies investigated how visual objects, as material, are seen, watched, touched, and carried [39]. The materiality of visual data has been addressed in terms of physical characteristics of media, such as print [16]. We recontextualize visual ethnography to address multimedia digital objects in the web browser. We develop materiality in terms of how digital found objects become recontextualized as material through curation.

Free-form curations function as meta-indexical representations through assemblage of web content [22]. Meta-indexical visual representations are not self-contained. They reference multiple meanings, which manifest through the viewer’s interpretation. In the present research, we investigate visual and conceptual means for the design of structures that extend the indexicality already inherent in the materiality of web content and its hypermedia links.

2.3 Pattern Languages

Alexander introduced the construct of *pattern language*, in architecture, for developing, “a solution to a problem in context,” which accounts for situated physical and cultural variables [1]. Pattern languages have been used in human-computer interaction to focus contextualized design and discussion [17, 10]. They have been used in software engineering as a means for codifying recurrent problems, solutions, and consequences [19]. Observing how patterns are used in practice has been shown to serve as impetus for reflection, discussion, and the derivation of implications for design [15].

2.4 Hypertext / Hypermedia

Free-form web curation is a type of hypermedia. Digital humanities scholar Bolter recognizes that hypermedia enables an author to represent a set of ideas as a web, which connects verbal and visual elements in a conceptual space [9]. Writer Michael Joyce creates hypertext works that help readers recognize and manipulate connections [23]. Spatial hypertext has been shown to support representation of early stages of design [35].

2.5 Information Composition

Information composition is a holistic medium of curation, which extends spatial hypertext to support ideation by promoting creative cognition of relationships among curated clippings and annotations [25]. Composition visually and semantically juxtaposes and contextualizes elements. Studies have shown that information composition supports ideation [25]. In the present research, free-form web curation extends information composition with sketching, multimedia, a zoomable user interface, and contextualization on the web.

2.6 Assemblage of Found Objects ⇒ Curation

We situate free-form web curation amidst art practices in which context transforms the meanings of found objects and their assemblages. Marcel Duchamp developed the *found object* conceptual construct by taking an ordinary article, exhibiting it with a new title, in a new context, and so transforming its significance [33]. Paul D. Miller, aka DJ Spooky, identifies the internet as a source of found object *material*, to be recontextualized in remix and mashup [34]. Assemblage is means for making a work of art by fastening found object materials together. Assemblage showcases the duality and tension between the original and resulting contexts [40]. Curation serves as a means for framing and conceptualizing how creative work and its contexts are understood [36].

In the twentieth century, practices of art and curation converged. In art, Dada [33] and Surrealism [12] launched the wave of art works made by appropriating and assembling found objects. Meanwhile, curation evolved from caring for a collection, to active specification and assemblage of new art works for a particular exhibition; curators, such as Lucy Lippard and Harald Szeemann, took the role of art creators [36]. Curation emerged as a distinct mode of discourse and framework for interaction across disciplines. Christiane Paul observes that new media art curation requires a “Parallel, distributed, living information space, open to artistic inference—a space of exchange and presentation that is transparent and flexible” [37].

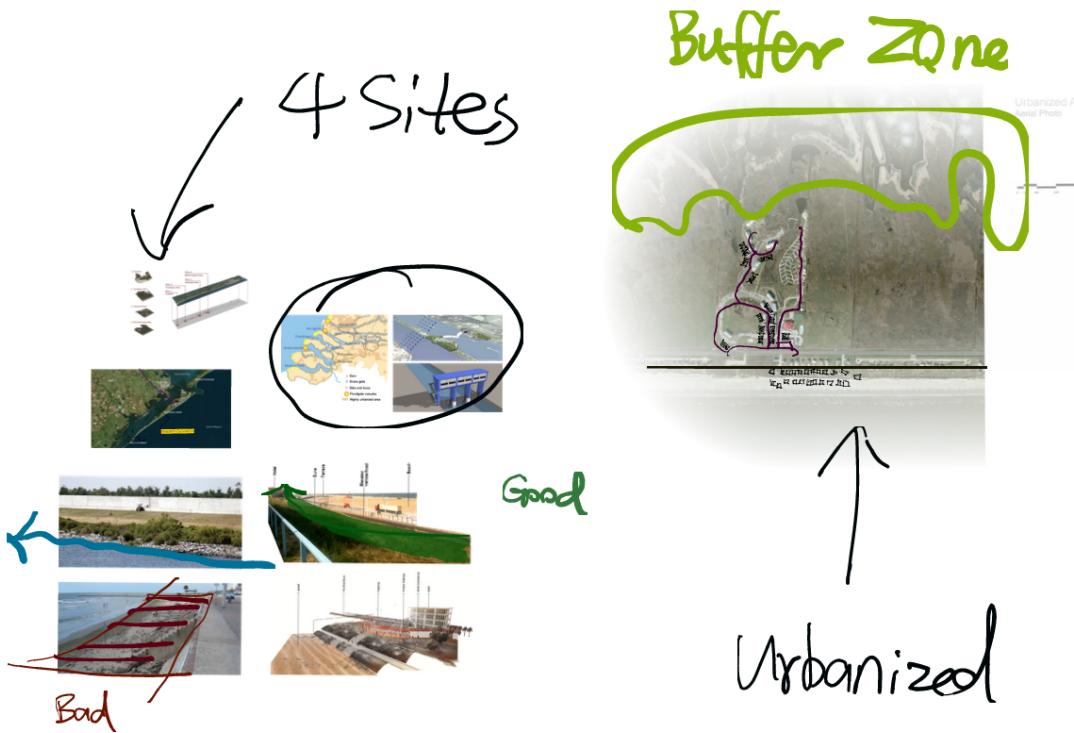


Figure 4: buffer zone (Professional Study) arranges beachfront and satellite coastal images in grids [<https://ideamache.ecologylab.net/v/6F7MNpHZ8K/>]. Visual thinking contrasts approaches to flood management in the Netherlands (“Good”) and Texas (“Bad”). Sketches over images analyze and abstract visual forms. *curation_patterns = {overlap|map, group|spatial}*

3. METHODOLOGY

Our methodology for investigating expression through free-form web curation was to conduct a field study across six courses, form a visual dataset, and analyze it with grounded theory methods. Through the analysis, we identified codes. Incorporating sensitizing concepts, we used the codes as the basis for a pattern language of visual thinking in free-form web curation.

Participating students used the IdeaMâché web curation app to create free-form web curations on various ideation assignments. IdeaMâché is characterized by a zoomable user interface, which enables assembling large amounts of content across scales. It supports collecting multiple types of elements: text, image, video, and sound. The user collects content elements through drag and drop in the web browser. Users can perform visual transformations on elements, including scale, rotation, Z-order, and opacity. Users can annotate their curations through sketching and writing with text.

3.1 Study Protocol

In our ongoing field study, we work with university professors to incorporate free-form web curation into coursework. In each course, before students perform assignments, we present an introductory lecture about web curation and the IdeaMâché app. Students then author free-form web curations as part of mandatory or extra credit ideation assignments. Instructors decide the number of assignments to offer and the specifications. Course instructors collaborate with us to design situated ideation assignments involving free-form curation.

While Institutional Review Boards emphasize confidentiality, we recognize the rights of student study participants to be credited for their creative work. Thus, our study protocol gives students the right to opt out, participate confidentially, or be attributed for their work.

3.2 Study Contexts: Courses

The six courses contributing to the dataset span four university departments: Environmental Design (1 course, 1481 students), Landscape Architecture (3 courses, 63 students), Communication (1 course, 22 students), and Computer Science (1 course, 15 students). Students and instructors in the computer science course are among the authors of this paper. Authors of this paper were not students or instructors in the other courses.

We formed the free-form web curation dataset by aggregating works authored by consenting students using the IdeaMâché environment, over 5 semesters, from the Spring 2013 semester through Spring 2015. Through 10 offerings of the 6 courses, 1581 participating students created a total of 4426 curations.

An introductory undergraduate environmental design course, *The Design Process: Creativity and Entrepreneurship* (DPCE), participated in the study over all 5 semesters. Students work as inventors and proto-entrepreneurs, creating concepts and sketches for innovations. On an open-ended ideation assignment, students chose a curation topic, e.g., wedding planning, workout routines, or personal health informatics (*Scoliosis*, Figure 1). Students also curated free-form *prior work collections*, each addressing needs, resources, and precedents for an innovation (*Laundry Notifier*, Figure 2).

Two undergraduate architecture courses participated in Spring 2015 and one graduate course in Fall 2014. In *History of Landscape Architecture I*, students curated to create ideas involving a historic landscape (Figure 5). In *Landscape Design IV*, student teams used curation for landscape design ideation. In *Professional Study*, a graduate studio, students gained experience designing for real-world sites incorporating photographs, satellite images, and geographic maps (*buffer zone*, Figure 4).

Pattern	Sub-pattern	Definition	Example Figures	Occurrences
<i>morphology</i>		The arrangement of elements corresponds to a recognizable form.		253
	<i>concrete</i>	The corresponding form is a physical or digital object or being.	1, 3, 5	
	<i>abstract</i>	The corresponding form is a map, shape, or plot.	1, 6	
<i>overlap</i>		The use of arrangement and transparency, such that elements coincide in the X-Y plane, and are stacked in Z.		385
	<i>compose</i>	The use of partial or complete overlap to strongly connect multiple elements.	2, 3, 5	
	<i>composite</i>	The use of alpha blending to visually synthesize multiple elements.		
	<i>map</i>	The underlying elements relate to a physical space or geographic area.	4	
<i>group</i>		Arrangement of elements to delineate distinct subsets.		830
	<i>spatial</i>	The use of positioning to create white space, which clearly separates one or more sets of elements.	1, 2, 3, 7, 6, 4	
	<i>nested</i>	The use of scale and arrangement to place some elements within the bounds of another.	2, 3, 5	
<i>path</i>		Arrangement of elements into one or more legible sequences. May involve connecting sketches.		537
	<i>linear</i>	A single, well-defined, ordered sequence.		
	<i>non-linear</i>	Branching, with subsequences that fork and junction, and / or with multiple connected components.	7	

Table 1: A visual thinking pattern language of free-form web curation, with examples. Occurrences denotes the number of times the pattern appeared among the 881 curations coded in the second round. In the text, we use the notation *major_pattern | minor_pattern*.

One upper level undergraduate communication course, *Cultural Studies of Communication Technology*, participated in Fall 2014. Each student created a free-form web curation in the ideation stage of the final paper (*Feminist Hashtag Activism*, Figure 3).

One graduate level computer science course, *Curation and Ideation meet Social Media*, participated in Fall 2014. Here, web curation served as a means of practice and as a subject of theory. Students used *IdeaMâché* for presentations on assigned readings and research projects (Figures 6, 7). Linder et al. studied how presentation with free-form web curation in this course stimulated open, free-form discussion in the classroom [31]; they did not analyze visual patterns.

3.3 Visual Grounded Theory Analysis

We took a visual grounded theory approach, performing initial and focused coding of the free-form web curation dataset. We formed an initial set of 44 curations by theoretically sampling the dataset through a situated, interpretive process conducted over time, in which teaching team members for the various courses and the *IdeaMâché* team identified best curations. Initial coding was performed by interpreting each free-form curation in terms of its visual and conceptual forms and writing down descriptors. These descriptors, or codes, could refer to the curation in part or as a whole.

We initially identified 13 unique codes. From these 13 initial codes, we formed a set of 9 focused codes by collapsing similar codes together. The process of deriving clear and distinct focused codes involved the researchers either choosing from the initial codes or synthesizing small subsets into combined codes. For example the two initial codes *design mimicry* and *shape nesting* were combined into the *morphology* focused code.

Using the focused codes, we performed a second round of coding of another 881 curations. These 881 curations were theoretically sampled from the dataset based on the Fluency ideation metric. Fluency, the quantity of elements, is an ideation metric [41, 25], which has been validated by creativity researchers as an indicator of creativity [20, 42]. We theorize that the Fluency metric tends to indicate significant design phenomena. The mean Fluency of the initial set of 44 curations was 79.8 elements ($\sigma = 70.6$). The mean Fluency of the second round subset was 79.1 elements ($\sigma = 38.6$).

We reached saturation and stopped coding. During the focused coding, we validated codes and organized them into distinct categories. We synthesized these categories into patterns of free-form web curation, which we describe in the next section.

Every individual act of building is a process in which space gets differentiated [p 19].

Each pattern is ... a bundle of relationships, capable of being different each time it occurs... A collection of these patterns, each one a fluid field... is capable of generating an entirely unpredictable system of new and unforeseen relationships [p. 223].

By building our lives out of these patterns, we are people of our culture [p 71].

—C. Alexander, *The Timeless Way of Building* [1]

4. PATTERNS OF FREE-FORM WEB CURATION

We use *pattern language* as a sensitizing concept to build on our visual grounded theory analysis of the dataset. A pattern language is a generative vocabulary for creative expression in some medium, be it physical architecture or free-form web curation. Patterns of spatial organization directly support patterns of human activity [1].

We sought to understand how typical students use free-form web curation as everyday designers [47] to engage in ideation [32] through visual thinking. We identified spatial patterns, in which students curate content in a manner distinct from practice with popular feed and board techniques. As in Dada, Surrealism, remix, mash-up, and everyday design, we expected to observe the appropriation of content as material. In contrast with Tufte [43, 44], we did not expect our investigation of everyday, mini-c visual thinking to identify groundbreaking techniques for the presentation of visual data.

We used our focused codes to derive a visual thinking pattern language of free-form web curation (Table 1). We identified major patterns and distinct categories within each. We define a notation for pattern types and sub-types: *major_pattern | minor_pattern*.

Like Alexander, we observe that patterns are combined in a great variety of ways in order to support human expression and activity as culture. Some patterns are complementary and often appear



Figure 5: Christina Vaughn’s *World* features bridge and skyscraper sketches [<https://ideamache.ecologylab.net/v/1MnMBuSkTs/>]. Vaughn appropriates and tiles photographs of historic buildings to fill in the skyscraper sketch. The curation gives form to ideation involving the recycling of building designs and materials. *curation_patterns = {morphology|concrete, overlap|compose, group|nested}*

together. For example, *group* is often used in conjunction with *path*; authors form sequences not just of individual elements, but of element sub-sets. Another complementary patterns example combines *morphology* and *overlap*; authors use Z-axis ordering to create larger shapes out of a set of elements.

As described above, we performed a second round of focused coding on 881 curations. Among these, we identified a mean of 2.69 patterns per curation ($\sigma = 1.14$). The distribution of occurrences of the patterns across the dataset is presented in Table 1.

4.1 Morphology

The *morphology* pattern visually arranges elements in a recognizable form, which may be concrete or abstract. A morphology conjoins visual structures to support gestalt reading of a curation [28]. The *morphology* pattern provides a basis for Tufte’s micro / macro designs [43], in which a form mitigates complexity by providing detail in one level of reading and serving as a texture in another. This supports interleaved levels of contextual interpretation.

morphology | concrete sometimes uses mimicry to creatively integrate form and content. In *Feminist Hashtag Activism*, Christine Lee instantiates this pattern by organizing her curation to mimic the layout of a Twitter page (Figure 3). Appropriated materials include the Twitter layout and linked hashtags. Lee uses morphology of these appropriated materials to create a holistic, meta-indexical perspective on the role of Twitter in contemporary feminism.

buildings made from older buildings

Christina Vaughn’s *World* exhibits *morphology | concrete* by tiling images of prior buildings within a sketched skyscraper (Figure 5). The new building is constructed by appropriating found objects. Her free-form curation develops and indexes a creative concept of creating new buildings, using old ones as material.

morphology | abstract enables authors to map a curation space to a mathematical or rhetorical space. Andrew Webb’s *graphic sign system: analysis of information* invokes the *morphology | abstract* pattern by organizing elements as a 2D plot (Figure 6). The elements are material clipped from Bertin’s *Semiology of Graphics* curriculum [6]. Along the x axis, labeled ‘concepts’, elements are positioned left to right, according to topic. Along the y axis, labeled ‘specifics’, elements are positioned according to level of detail. More general elements are at the bottom, with more specific elements placed toward the top of the graph.

The top half of *Scoliosis* (Figure 1) exhibits the *morphology | concrete* pattern. Top center, Kimmel sketches a curved spine. Sets of content elements, addressing aspects of the disease, are rotated to align with vertebrae. The next vertical segment is organized as a 1D plot, instantiating *morphology | abstract*. The axis is labeled according to the severity of spinal curve deformation. Exhibition forms below the axis correspond to associated treatment options.

4.2 Overlap

The *overlap* pattern assembles elements using X-Y positioning,

specifics

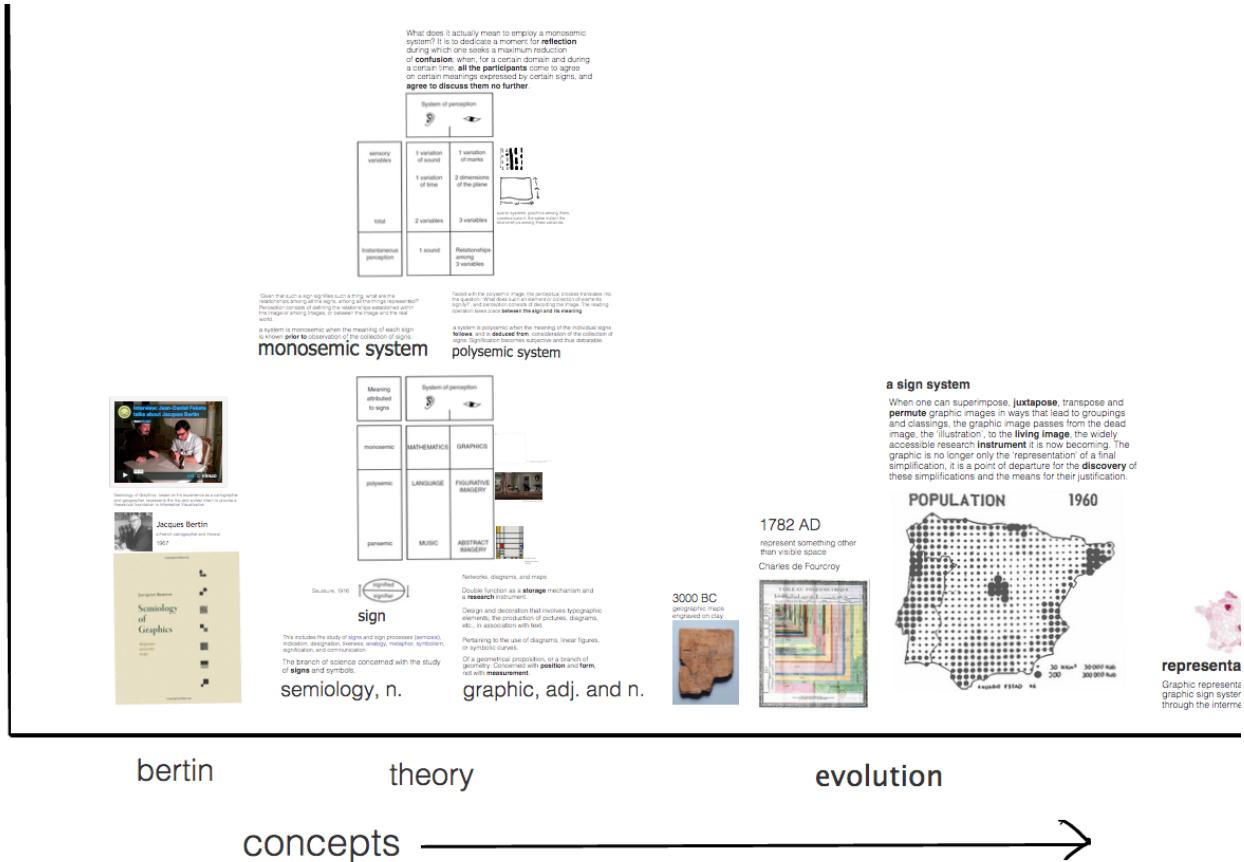


Figure 6: Andrew M. Webb curated *Graphic Sign System: Analysis of Information as a visual aid for his presentation on Bertin's Semiology of Graphics: Diagrams, Networks, Maps [6], in the Curation and Ideation meet Social Media seminar [<https://ideamache.ecologylab.net/v/Hz9Ky6Uh6x/>].* Webb creates conceptual axes in order to visually and semantically organize Bertin's concepts for information presentation, while meta-indexically invoking these concepts. *curation_patterns = {morphology|abstract, group|spatial}*

Z-ordering, and transparency. Using overlap in free-form web curation manifests Tufte's principle of layering information to express relationships and adds dimensionality in a visualization [43]. Arnhem shows how overlap intensifies formal relations by concentrating them within tightly integrated patterns [2].

Overlap sub-patterns address how layers give form and support abstraction. *overlap | compose* combines elements to create a coherent whole. Some elements function as background and others as foreground. Sketching over is a common technique here. *overlap | composite* invokes image translucence to create new visual syntheses. *overlap | map* places foreground elements over a geographic map or other image of a physical place, relating curation space to physical or geographic space.

Background elements provide a basis for the *overlap | compose* sub-pattern. Sometimes a single visual comprises the background. In the innovation curation, *Laundry Notifier*, Jump appropriates a washing machine image as thematic background (Figure 2). In *Feminist Hashtag Activism*, Lee assembles linked content elements mimicking tweets on a Twitter feed template background (Figure 3).

Other forms of *overlap | compose* assemble repeated found elements. *Christina Vaughn's World* (Figure 5) tiles images of a day and a night sky. With visible seams, the assemblage illustrates a world that is simultaneously natural and manufactured.

Another pattern subtype is *overlap | map*. Exhibition forms are placed over a representation of a physical space, such as a geography or blueprint. *buffer zone* (Figure 4) exhibits multiple instances of

mapping. The author sketches texts and glyphs over photographs of beach fronts and satellite images.

Mapping through *overlap* differs from the *morphology* pattern, in that elements are arranged in correspondence to an inherently spatial representation. To differentiate between mapping and morphology, consider the following case. A curation that plans an Italian vacation by arranging elements in the shape of Italy exhibits *morphology*. A curation that places elements on a map or satellite image of Italy exhibits *overlap | map*. Mapping creates proportional relationships between exhibition space and physical space.

4.3 Group

The *group* pattern uses spatial arrangement to associate elements into distinct subsets. It is the most common pattern. Creating relations through proximity or visual similarity is a fundamental design practice [30]. *group | spatial* uses white space and rotation in the X-Y plane to separate a selection of elements. *group | nested* uses scale and the Z dimension as a means for group delineation.

The lower half of *Scoliosis* (Figure 1) uses the *group | spatial* pattern. Elements are organized with proximity. White space separates the sets. While the bottom left group addresses awareness, the bottom right assembles personal stories of scoliosis and treatment, ending with, 'My Curve', which links to Kimmel's personal blog. *Scoliosis* also invokes rotation as a *group | spatial* technique. In the top half, the author delimits groups of content elements by rotating them in alignment with vertebrae in her spinal curve sketch.

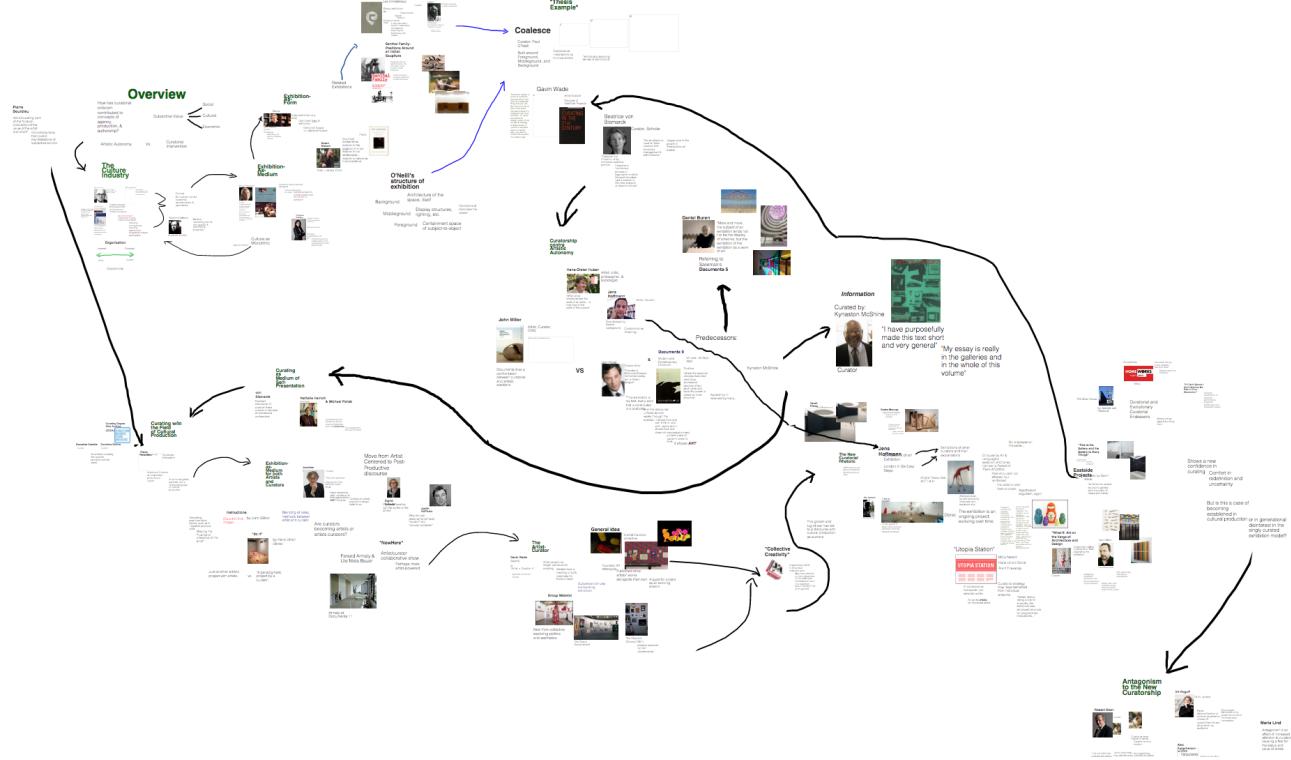


Figure 7: Trey Rhody’s *curation 2*, a visual aid for his presentation on a chapter of O’Neil’s book [36], in *Curation and Ideation meet Social Media* [<https://ideamache.ecologylab.net/v/WclWQvZdT/>]. Rhody created an extensive non-linear path of exhibition form elements to illustrate and relate art curation practices. *curation_patterns* = {group|spatial, path|non-linear}

Laundry Notifier (Figure 2) uses scale to exhibit the *group | nested* pattern. The nested groups—addressing design ideas, existing patents, notification methods, and partnerships—can be read at the overview level. The elements within these groups are smaller, requiring zoom in for details to become legible. Through *group | nested*, a curation exhibits different amounts of information at different levels. This suggests the *semantic zooming* information visualization technique, in which the representation of information, as well as its size, changes in response to changes in visual scale [38].

Christina Vaughn’s World (Figure 5) exhibits *group | nested* in a different way. In overview, the curation presents a gray skyscraper with a sketched outline. Zooming in on the skyscraper, we find its walls are a texture of tiled image found objects. Each tile can be read individually as a photo of an old building. *group | nested* is invoked with scaled, found images to convey a concept of reuse.

4.4 Path

The *path* pattern arranges found, sketched, and written elements to form one or more sequences, which may branch. Paths constitute a form of node-link diagram [48], reminiscent of Tufte’s links and causal arrows, which are used to depict associations and relationships [44]. Curators use connecting glyphs, such as lines and arrows [45], to create paths that indicate relationships among elements. Connecting glyphs can be sketches drawn by the author or found digital images that the s/he has collected.

In addition to glyphs, authors use writing to create texts to describe a path’s structure. Common examples include ‘start here’, ‘read this first’, or explanations of a path as a whole. A curation can incorporate a single *path | linear* connected component or multiple connected components as the *path | non-linear* pattern.

Rhody’s *curation 2* (Figure 7) exhibits *path | non-linear*. Sketched arrows connect conceptual groups and sub-groups. The starting point of the non-linear path is in the top left, where he wrote ‘Overview’. From this initial group, the path splits. The reader can choose to move down or to the right. We also see that Rhody has created multi-directional relationships among groups, illustrating a multiplicity of interconnections among his exhibition forms. Through *path*, curation authors articulate narratives that scaffold presentation and interpretation.

5. IMPLICATIONS FOR DESIGN

The present research investigates students’ creative practices in a range of courses to discover a pattern language of visual thinking with in free-form curation. From the patterns, we derive implications for the design of web curation apps. First, by supporting free-form assemblage, enable authors to create design synthesis, visual thinking, and meta-indexical structures in online exhibits. Next, support authors in creating emergent ideas by constructing visual hypermedia narratives. Third, enable authors to create analogical mappings between representations of spaces with overlap and juxtaposition.

5.1 Free-form Assemblage

Kolko notes that designers visually explore quantities of seemingly unrelated material to discover hidden, relationships [26]. He explains how continuous rearrangement and work across scales facilitate design synthesis. This process of synthesis matches Arnheim’s findings of the roles of exploration, analysis, and synthesis in visual thinking. Synthesis is a generative process of ideation [18].

Free-form assemblage serves as a means for authors to engage in continuous rearrangement, visual exploration, and discovery.

The four major free-form curation patterns—*morphology*, *overlap*, *groups*, and *paths*—function as ideation structures of design synthesis and visual thinking.

Web curations index concepts through the morphology pattern of assemblage of exhibition forms. For example, the morphology of *Feminist Hashtag Activism*, indexes the social medium of Twitter, the concept of hashtag, and specific hashtag instances (Figure 3). In Webb's *Graphic Sign System: Analysis of Information*, exhibition forms and writings are assembled into a 2D map. The assemblage connects form and content by manifesting graphic system principles described in its elements (Figure 6). The curation thus indexes semiotic graphical system concepts contained in its assemblage.

To support free-form assemblage, web curation environments must incorporate design tools for graphical manipulation of position, scale, and other visual characteristics of exhibition forms. Such free-form assemblage capabilities will enable authors to encode new meanings via structure and design. This will provide new opportunities for authors to develop emergent and meta-indexical syntheses and juxtapositions on the web.

5.2 Visual Hypermedia Narratives

Authors use free-form web curation to develop emergent ideas through visual hypermedia narratives. Through spatial arrangement, visual transformation, writing, and sketching, authors create linear and forking [11] paths within their curations. These visual hypermedia narrative pathways give form to what Landow [29] identifies as Barthes' “ideal textuality”—in which plural networks of elements extend, supporting multiple interpretations [4]. A visual hypermedia narrative uses storytelling to express relationships over time, while exhibiting a multiplicity of framings, uses, and outcomes.

curation 2 (Figure 7) uses a web of paths to construct a complex, interconnected narrative. Rhody groups exhibition forms and writings around “Documenta 9”. He adds a label, “Predecessors”, with two outgoing arrows, one pointing to Daniel Buren and the other to Kynaston McShine. This structure supports the reader in choosing her own progression through *curation 2*'s 392 exhibition forms.

The visual hypermedia narrative in Kimmel's *Scoliosis* is less explicit. Starting at the top, one is drawn downward, following a sketch of the spine. The reader learns about scoliosis through groups of exhibition forms and writings, placed alongside the spine, and rotated to index the spinal curve. At the base of the spine, the curation reads from left to right, along a single axis graph of spinal curve severity, with corresponding treatment options. Below, are two groups of exhibition forms. One is labeled “AWARENESS.” The other is labeled “My Curve.” It indexes Kimmel's personal blog, which details her own experiences with scoliosis. We interpret the overall narrative as conveying challenges and hope.

Free-form capabilities in web curation apps enable users to draw from navigational aids—such as writing, drawing, and positioning—to construct visual hypermedia narratives. These help authors to guide viewers through their curations. As the number of exhibition forms and their visual complexity increases, does the need to support narrative structure construction in web curation.

5.3 Mapping Spaces

Another design affordance of free-form curation is enable mapping and indexing spaces. Distance and proximity within a digital space of web curation can be designed to directly correspond to physical or geographic space represented within exhibition forms. These mappings can be abstract, such as placing exhibitions forms on graphs or plots, or they can be more concrete, such as placing forms on maps, satellite images, or blueprints.

For example, *buffer zone* (Figure 4) overlays sketches on exhibi-

bition forms representing particular physical spaces. The author arranges photographs of beach fronts and satellite images into two columns, representing specific regions: Texas and the Netherlands. In the top row, maps of the Texas and Netherlands coastlines are adjacent. The middle row overlaps sketches of forms on images of Netherlands beaches, with the label, “Good.” The bottom row, a parallel structure, overlaps sketches on Texas beaches, with the label, “Bad” The curation juxtaposes alternative coastal designs. This visual analogy compares approaches to flood management, and their effects during natural disasters such as hurricanes. Visual analogies serve as valuable means for thinking about and developing emergent concepts and ideas. Free-form web curation supports visual thinking through the mapping of spaces.

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7. CONCLUSION

Free-form is valuable as a new medium of web curation for a broad range of intellectual work, because it supports ideation through visual thinking. We know this because of the observed range of patterns manifested in the visual dataset and the concomitant range of invocations of the patterns in the performance of ideation tasks. Their aggregation as a pattern language provides a basis for potential recombination in an infinity of emergent relationships.

The present research makes visual data and its analysis primary, because our focus is visual thinking and expression. We took an art-based approach, seeing and interpreting creative products as visual data. As Berger says, “Seeing comes before words... Every image embodies a way of seeing” [5]. Through the invocation of patterns of free-form curation, our study participants interweave seeing, collecting, organizing, and visual thinking to achieve ideation.

We investigated a dataset of thousands of free-form web curations, created by students in a variety of courses, to fulfill ideation assignments. We observed that ideas take shape through concrete and abstract morphology (253 instances), composed, composited and mapped forms of overlap (385 instances), spatial and nested groups (830 instances), and linear and non-linear paths (537 instances). The patterns capture visual, material and indexical characteristics of exhibition forms, and of their assemblages, as wholes.

A large population of students in a range of fields—e.g., humanities, science, and entrepreneurship—engaged in visual thinking and ideation with the patterns. We primarily identify their activity as mini-c and little-c creativity, that is, expression significant to themselves and their courses, rather than to society at large. These everyday students engaged in a form of curatorial practice akin to that in the arts, where curators design exhibits in which they choose and assemble objects created by others, and spatially organize them, along with their own interpretive writing and sketching.

These everyday visual thinking curatorial practices differ from curation in the most popular web apps—Facebook, Pinterest, and Twitter—whose feeds do not now support visual thinking through free-form curation. Our evidence motivates the incorporation of capabilities for free-form assemblage, visual hypermedia narratives, and mapping spaces in social media and productivity environments.

Gestalt psychologists, for over a century, have recognized grouping—through principles such as proximity, color, size, orientation, region, symmetry, continuity, and closure—as the fundamental

means of visual organization [46]. We see these gestalt visual principles manifested in the present patterns of free-form web curation. Across the patterns and dataset, everyday users invoke gestalt principles to engage in visual thinking through free-form web curation.

Free-form web curation is in infancy. We make no claim that the present set of patterns of free-form web curation is complete. We hope and expect, with wider adoption and practice over time, that continuing research will discover a wider and deeper pattern language of free-form web curation, more closely resembling Alexander et al.'s in specificity, nuance, and extent.

Free-form web curation moves toward the flexible space of exchange and presentation that Christiane Paul, new media curator at New York's Whitney Museum, requires for new media art [37]. The growing pattern language of free-form web curation advances how humans draw on the incredible resources of the internet, as building blocks of visual thinking, and so promotes our fulfillment through expression, ideation, and innovation.

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