

Strategies of Free-Form Web Curation: Processes of Creative Engagement with Prior Work

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ABSTRACT

We synthesize principles across art, design, writing, and psychology to articulate strategies of free-form web curation, for stimulating students' creative engagement with prior work, in performance of ideation tasks. We manifest the strategies in an interactive system and pedagogy. *Free-form web curation* is a form of new media—designed to enable users to conceptualize and create new contexts—in which they discover, interpret, and represent relationships, by composing readymade and self-made content elements. The strategies are Collect, Assemble, Shift Perspective, Sketch, Write, and Exhibit.

We conducted a field study involving 1247 students over 4 semesters. We connect visual, quantitative, and experiential data to show how students engage with prior work through the free-form web curation strategies, system, and pedagogy. We develop implications for design of web curation systems and education. We coalesce a theory of free-form web curation, based on the strategies, emphasizing space and context.

Author Keywords

curation; ideation; art; design; creative cognition; visual thinking; creativity support tools; education; theory

INTRODUCTION

We synthesize principles across art, design, writing, and psychology to articulate strategies for engaging students' creative cognition with prior work, in performance of ideation tasks. We manifest the strategies in an interactive system and pedagogy for free-form web curation. By *prior work*, we mean germane web content, especially articles and patents. An *ideation task* [89, 45], in turn, involves generating and developing new knowledge for a project intended to be innovative. Understanding prior work is key to innovation in many fields [67]. In industry, failure to use the external knowledge of prior work produces severe competitive disadvantage [14].

The problem addressed by this research is that discovering relationships connecting prior work and the ideation task at hand is challenging. Processes of creating new knowledge

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are iterative and emergent [26]. Multiple prior knowledge elements need to be interpreted and combined in new ways [62]. Linear media—such as print documents and lists of entries—only enable sequential arrangement, and so make it difficult to discover relationships spanning multiple elements [68].

Our solution to the problem of supporting users in discovering relationships connecting prior work, in an ideation task, is based on art practices involving found objects and curation. Duchamp's seminal work showed how shifting the *context* of a *found object*, or *readymade*, has the potential to transform its significance [56]. Recent popular media notions of curation, while encouraging, have been reductionist, emphasizing 'adding value' by collecting and commenting, using linear social media such as the blog and feed [81]. In art, in contrast, *curation* grew, beyond 'adding value', to become the conceptualization and creation of a context, in which works are found, collected, interpreted, and visually arranged, in an exhibition space, to stimulate active engagement [69].

Free-form web curation is a form of new media [59]—designed to support users in creating new conceptual and spatial *contexts*—in which they discover, interpret, and represent relationships, by composing readymade and self-made content elements, on the web and in the cloud. This paper articulates how we drew from diverse fields to define creative strategies of free-form web curation: Collect, Assemble, Shift Perspective, Sketch, Write, and Exhibit. We invoked the strategies to design both an interactive system, IdeaMâché [<https://ideamache.ecologylab.net>], and pedagogy, for teaching students how to creatively engage with prior work.

Process—emphasis on engagement, on doing, on the often ineffable *how* that making is performed—and *product*—emphasis on results, on *what* is produced—are complementary aspects of creativity [84]. Prior research used visual grounded theory [47] to derive a pattern language of free-form web curation, by analyzing students' creative products, in diverse courses, to understand the range of spatial organization of readymade and self-made elements [58]. Like Alexander's pattern language of architectural forms, which support human physical activity—e.g., alcoves, arcades, and promenades [1]—the free-form curation patterns—*overlap*{*compose, composite, map*}, *morphology*{*concrete, abstract*}, *group*{*spatial, nested*}, and *path*{*linear, non-linear*}—were shown to map the multi-scale organization of digital design space to human ideation activity. We further showed that the patterns support

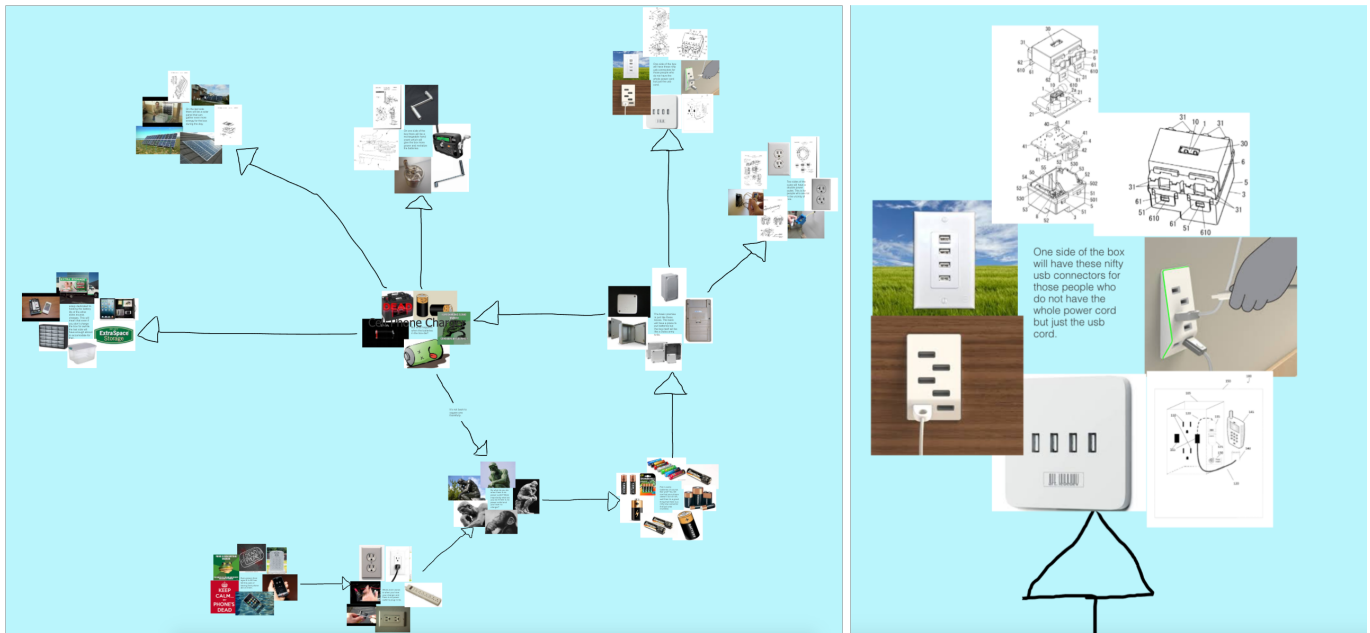


Figure 1: Cell Phone Charger develops a narrative diagram of nodes, each with centered text surrounded by a circle of graphics (left) [<https://ideamache.ecologylab.net/v/pfrBCKmBSB/>]. On the right, we see a close-up of a node addressing techniques for arranging USB sockets on the proposed innovative charging device. The author incorporates prior work patent sketches and commercial product illustrations, which serve as evidence to motivate the novelty of the innovation.
curation_patterns = {group|spatial, path|non-linear}

creative cognition and visual thinking, manifesting gestalt principles of visual organization [72]—e.g., proximity, color, size, orientation, region, symmetry, continuity, and closure.

The present research addresses gaps in prior research, by alternatively focusing on fundamental *processes of doing free-form web curation*: the ideation tasks that people perform; creative strategies that contribute to performing these tasks; principles and precedents, from across fields, which underlie the strategies; the *IdeaMâché* web app [39], which provides integrated support for invoking the strategies online; and pedagogy for teaching people how to use strategies of free-form web curation to engage in creative ideation with prior work and beyond. Other prior research showed how using free-form curation products for presentation, in the classroom, stimulates free-form discussion [54].

We present a field study involving 1247 students over 4 semesters. We show exemplary curation products, as visual data, which depict students' creativity (Figures 1, 3, 4). We use process-oriented engagement analytics to examine how students use the interactive free-form web curation system, *IdeaMâché*, to perform the strategies. We contrast the present approach with prior systems for engagement with prior work. We connect findings with the strategies to develop implications for the design of web curation systems and education. We conclude by coalescing a theory of free-form curation spaces.

STRATEGIES

According to National Academies' learning scientists, pedagogy needs to involve strategies that help students think about

concepts, organize them, and overcome difficulties they encounter [10]. Strategy is, "the art or practice of planning the future direction or outcome of something; the formulation or implementation of a plan, scheme, or course of action" [71]. We take a discursive approach [21] to defining strategies for curation, drawing from diverse fields, including art, design, writing, cultural theory, creative cognition, and hypertext.

A student finds content elements—germane to her ideation task—in digital repositories, social media, and other websites. She *Collects* these found objects, from initial contexts, into a new *context of curation*, to understand and create a conceptual basis for her ideation task. As in art, to understand, articulate, and interpret relationships, she *Assembles* collected elements in space, which stimulates reflection. To navigate the curation space, students and the professor *Shift Perspectives*, seeing things in different ways. She *Sketches* to represent and generate diagrammatic visual thinking. She *Writes* to categorize, present evidence, and develop exposition. *Exhibiting* presents curation contexts to audiences. We illustrate strategies with exemplary principles and practices.

Collect

Collect is the process of gathering content. Collecting prior work is the basis of the time-honored notion of "doing research in the library" [94]. We draw on Rosenberg's concept of a 'gathering interface', which enables collecting content, while browsing, and assembling elements using the 'conjunctive method' of spatial hypertext [82]. Since content to collect is usually found through exploratory search [60] (e.g. by iterative Googling), it makes particular sense to frame collecting content in terms of art's construct of found objects.



Figure 2: Rauschenberg's *Retroactive I*, 1963, a mixed-media assemblage from the *Combine* series.

Marcel Duchamp recontextualized a *found object* (or *ready-made*)—specifically a urinal—to function as an artwork in a prominent 1917 exhibition [56]. He (re)titled the work, *The Fountain*. He used a pseudonym, R. Mutt. The exhibition organizers were upset. They only permitted *The Fountain* to be exhibited in a separate room. While the exhibition included over 2000 art works [91], some by well-known artists, *The Fountain*, a ‘simple’ found object, is the most famous.

Duchamp said, “Mr. Mutt did not make the work, he chose it” [56]. Duchamp’s *Fountain* and explanation transformed our understanding of the action of choosing into a creative act, with great power of signification. By manipulating the title and author of the work, Duchamp explored the contextual role of metadata in signification. Through its fame, paradigmatic influence on art, and ability to explain popular practices in social media, we argue that *The Fountain* was the most significant art work of the twentieth century.

An example of the recontextualization of found objects in social media involves Meryl Streep’s Golden Globes award acceptance speech. Streep expressed how Donald Trump’s imitation of a disabled reporter broke her heart [96]. Trump’s tweet lambasting her, in response, has, as of this writing, been retweeted 38K times and liked 127K times [97]. Through its recontextualization on Twitter, the initial speech, as found object, became, for some, a signifier of ‘Hollywood elites’ [63].

Assemble

Assemblage is means for making a work of art, attributed to Dubuffet, by fastening readymade and self-made elements

together [87]. Assemblage showcases the duality and tension between the original and resulting contexts. The means of ‘fastening’ vary with different media. Assemblage begins with making elements coincide in space. Assemblage is related to De Landa’s notion of *aggregate*, which occurs in physical geography and geology, such as when silt and rocks are deposited in piles by currents in a stream [19]. In aggregates, while a new whole is formed, at the same time, constituent elements retain their characteristics and identities.

Assemblage has the potential to stimulate *emergence*, in which people identify new properties beyond the characteristics of the elements. Wilkenfeld and Ward showed that combination of disparate elements is particularly likely to stimulate emergence [101]. The assemblage stimulates the viewer to think about unexpected relationships.

Putting elements together in space is a key strategy of art, curation, and hypermedia. Arranging elements in space can create a multiplicity of relationships, which stimulate the curator to interpret meanings during the creative process, and the viewer to do so subsequently. During iterative processes of knowledge creation, cycles of creation, interpretation, and reflection form what Schön calls, *reflection-in-action* [85], and Webb et al call, *reflection-in-curation* [100]. The representation “talks back” to the author / user [66].

Media Art Forms of Assemblage

Duchamp’s strategy of the readymade found object became an extensive basis for recombinant media [44] art in the twentieth and twenty-first centuries. Found objects are juxtaposed, combined, and composed to form a whole in a panoply of assemblage forms: e.g., collage, pop art, music of indeterminacy, music concrete, remix, and hiphop. Max Ernst was an exemplary collage artist, who assembled found objects with his own sketching and overpainting [92], to construct new schemas of techno-culture [48]. Warhol’s pop art appropriated popular media images—e.g, Marilyn Monroe and Mao Zedong—and directly re-presented them with media such as painting and printmaking. According to Higgins, examples of ‘intermedia’ include Oldenburg’s *Floor Burger*, made of acrylic on canvas filled with foam rubber and cardboard boxes, which “falls between sculpture and hamburgers”; and Rauschenberg’s ‘combines’ (Figure 2), which assemble popular media images with sketching and painting to create cultural statements [35].

Cage composed found sound sources, such as random FM radio transmissions, as instruments in the *Imaginary Landscapes* music of indeterminacy series [12]. DJ Spooky identifies the internet as a source of material, for remix; he defines DJing in terms of ‘rhythm science’, in which “endless recontextualizing is a core compositional strategy” [65]. DJing, the gathering, playback, and remix of audio samples, is, along with rapping, the compositional method of the popular genre of hip-hop, a multi-billion dollar popular music industry [99].

Spatial Hypertext and Information Composition

Spatial hypertext enables freely creating and moving nodes, expressing relationships through proximity [62]. Spatial hypertext’s flexibility supports iterative change through design

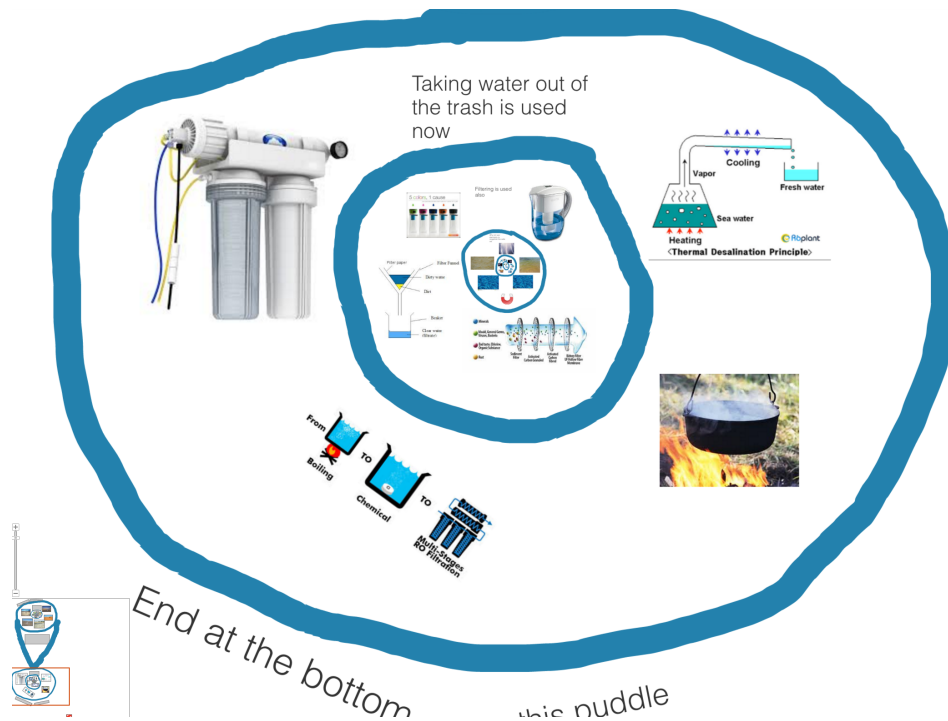


Figure 3: The *Water Cleaning* curation uses roughly sketched concentric circles, labeled as ‘puddles’, as a metaphor for the significance of rain water [https://ideamache.ecologylab.net/v/m7K4sfTCF3/]. The whole, seen in IdeaMâché’s radar view (bottom left), is an exclamation mark. The top puddle, just in the radar view, illustrates the problem of desertification. The bottom puddle, comprising most of this figure, addresses solutions, beginning, at this level, with prior work. $curation_patterns = \{morphology|concrete, group|nested\}$

processes. It helps express speculative, contingent, and informal relationships [7]. Information composition extended spatial hypertext—by emphasizing the visual and a sense of the whole—to promote the creative cognition of relationships among elements [45]. Elements function as hypersigns—i.e., signifiers hyperlinked to signifieds—which are semiotically assembled to create new meanings [42].

Shift Perspective

Shifting perspective while navigating space is essential to human experiences of physical exhibitions. Concepts of *Shifting Perspective* in space come from architectural design, cultural theory and computer graphics. Courajoud makes the concept of the horizon—which implies extreme traversals in distance and scale—central in landscape architecture [18]. He argues that scales must be linked.

Allen offers the field, a spatial matrix capable of unifying diverse elements, while respecting the identify of each [2]. The field is a site of aggregation and a space of assemblage. Field configurations are incrementally expandable.

Sellen and Harper observe how people use the affordances of paper for reading and writing [88]. People shift pages around to organize information spatially, compare elements, and extract from one to another. Continuously shifting spatial organization was found to facilitate annotation.

When an exhibition is created and presented in physical space, viewers navigate by moving their bodies. Paradigms based in computer graphics have been developed for representing space and navigation in virtual space. Pad provided a ‘spatial metaphor for computer interface design’, through an infinite 2D information plane, with levels of zoom, on which elements were organized geographically [74]. Zoomable User Interfaces (ZUIs) generalize this approach, using changes of scale as a principal means of organizing content and navigation [5].

Sketch

Sketching ... [is used] to diagram or depict abstract or concrete states (for example a family tree or an electric circuit scheme), maps and plans (such as instructions for finding the way or furniture layouts), signs or things, live or inanimate, real or imaginary. But ... some [sketching] does not follow ideas in the mind, but instead, precedes them... not to record an idea, which is not there yet, but to help generate it.

–G. Goldschmidt [30]

Merleau-Ponty shows how perception, itself, is inherently based in the body’s memories and interpretations [64]. *Visual thinking* intertwines perception, recognition, and reflection in creative acts of forming and illustrating new meanings [3]. Sketching is an embodied physical process of visual thinking. Goldschmidt explains how designers sketch to generate forms that they imagine [30]. Through reflection-in-action [85], in turn, sketching generates new form combinations.

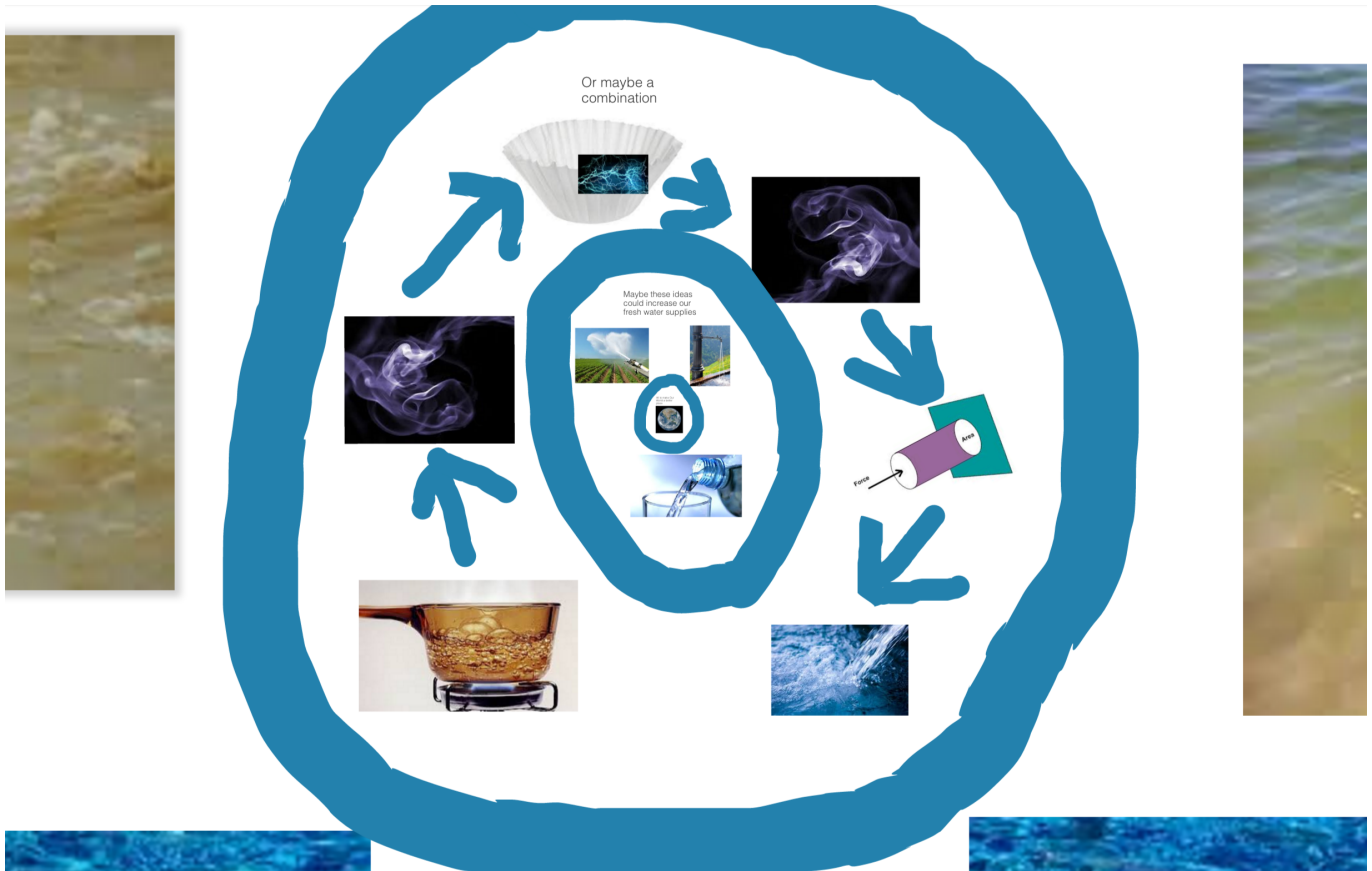


Figure 4: Navigation into bottom puddle of the *Water Cleaning* curation, by zooming in using the scroll wheel. Successive levels of zoom take us deeper into the student’s innovation, which combines thermal, filtering, and desalination techniques. Through zoom, an additional curation pattern emerges: *path|non-linear*.

Larkin and Simon show how diagrams are easier to understand than lists of relationships [52]. Benefits include using position to group information and making inferences easy to perceive. Diagrams predate written language as a form for inscribing communication. Tversky characterizes *glyphs* as simple figures— e.g., points, lines, and arrows—which draw from their context to articulate meaning [98]. She emphasizes the role of human interpretation in creating and understanding the meanings of glyphs and other visual elements in context.

Write

Following sketching, writing, as represented in ‘print’, was, until recently, the predominant medium of communication. According to Ong, a new medium transforms those that precede it, while enabling new forms of communication [70]. As a curation strategy, writing takes multiple forms, differentiated by length, function, and structure: exposition, hypertext, annotation, and labeling. Expository and creative writing involve longer textual passages. The fixity of print enabled the composition of complex literary works, such as the novels of James Joyce, as well as complex arguments, such as those in scientific analysis.

Traditional expository writing is linear. Free-form web curation with prior work serves as a medium for ideation in con-

nection with expository writing. As in recombinant media of assemblage, juxtaposition plays a key role in expository writing across fields. Other aspects of writing are field specific. How the role of voices and their authority is left implicit or made explicit is an aspect of writing that varies. Writing in art history involves criticism, formal analysis, concrete facts, and theory [76]. In social anthropology, it involves entering a conversation, borrowing, extending, establishing authority, and stepping back [16]. In sciences, writing is based on the quality and quantity of evidence, which in turn is based on the formation and validation of hypotheses, the design of studies, the analysis of data, and the interpretation of results [13]. Business models present evidence and arguments about partners, activities, resources, value propositions, customer relationships, customer segments, channels, cost structure, and revenue streams [8].

Recent writing forms are shorter and non-linear. Bolter shows how hypermedia writing spaces enable multiple paths of navigation and processes of interpretation [9]. Landow cites Nelson [68], Barthes [4], and Foucault [27] to show how hypertext enables ‘ideal textuality’, in which networks of lexia support multiple voices and interpretations, giving the active reader creative agency, in tandem with the writer [51].

Annotation involves highlighting, clipping, and commenting. Marshall's investigation of practice with physical media, as a basis for hypermedia design, shows the role of annotation—as a means of emphasis, interpretation, and reflection—in the transformation of authorial structure into reading structure [61].

Russell et al investigate how the labeling of content elements becomes transformed, in sensemaking tasks, from an initial schema, based on source materials (prior work), through a representational shift, to a task-specific schema [83]. Kolko identifies, as a key technique in design process, the articulation of semantic relationships, which help 'make meaning out of data' [46]. To accomplish this, elements are spatially manipulated on a 'big wall'.

These findings emphasize the role of what we call *curation context*, based on an ideation task at hand, in creative written engagement with content. Lakoff and Johnson provide insight into underlying human cognition, explaining how naming concepts and spatially relating them, through metaphors, forms a basis for understanding and comparison [50].

Exhibit

In the twentieth century, the role of the curator was transformed from carer to author of exhibition-texts [69]. The museum was transformed from historical repository to place for exhibitions. Curating emerged as a mode of discourse¹.

Lippard [57] and Szeemann [20] exemplify the contemporary paradigm of curators who take an especially active role in how they organize exhibition contexts. They articulate a conceptual nexus. They choose artists as well as works. They conduct open calls. They commission works. They encourage artists to make site-specific artworks specifically for the spatial and temporal context of an exhibition.

One large-scale exhibition context is *documenta*, a festival conducted every 5 years in Kassel, Germany. In addition to a permanent exhibition complex, which itself can be reconfigured, large and small scale pop-up sites are constructed around Kassel. Artworks are specifically designed for these sites. Szeeman was the curator of *documenta 5*, which he titled "Questioning Reality — Pictorial Worlds Today" [22]. The exhibition assembled diverse artworks—abstract, dada, intermedia, and happenings—created by 222 artists.

Multi-scale free-form space moves toward fulfilling Christiane Paul's requirement for new media art curation, toward providing "Parallel, distributed, living information space, open to artistic inference—a space of exchange and presentation that is transparent and flexible." [73]

IDEAMACHE: SYSTEM

We present the free-form web curation system, IdeaMâché, in terms of the strategies: Collect, Assemble, Shift Perspective, Sketch, Write, and Exhibit. Each strategy is supported through one or more interactive operations, which users can directly perform.

¹According to Habermas, a discourse is a collection of utterances, which take place in particular social contexts and are subject to inherent limitations of time and space [31].

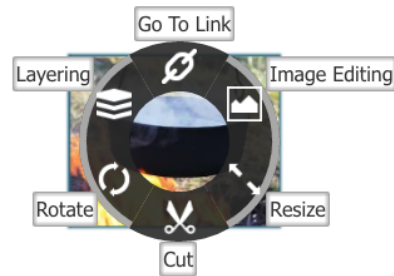


Figure 5: Marking menu: actions operate on an element.

Collect: Direct Clipping

IdeaMâché manifests the *Collect* strategy by enabling direct manipulation [37, 90] clipping of web information. By *clipping* (verb), we mean the act of selecting content in a source context, such as a web page or social media post, and gathering that content in a new curation context. The resulting object, sheared from its source, is a *clipping* (noun).

IdeaMâché supports direct clipping through a Chrome browser extension that transforms encountered web content into material [29]. The browser extension interjects a drag event handler into each encountered web page. The user Collects by selecting content to clip and performing the across windows Drag and Drop operation.

On drag, a semantic summary of the source web page context is captured. The selected content is augmented with the contextual semantics, forming a *rich clipping*. Contextual semantics are captured with a type system, which integrates data models with extraction rules [43, 78]. Contextual semantics minimally include the source document's URL and title. Depending on their type (e.g., social media post, product, scholarly article, or patent) rich clippings may contain further semantics, such as references and citations. Rich clippings can incorporate diverse types of web media: text, image, audio (SoundCloud), and video (YouTube, Vimeo, Twitch).

Assemble: Visual Arrangement and Transformation

To support the *Assemble* strategy, IdeaMâché enables selecting and manipulating elements in a curation space. The Position operation is performed, through direct manipulation, by left click on an element, and drag. A marking menu [49], activated by right click, is used for rapid selection of other Assemble operations, as well as multi-element select (Figure 5).

Some Assemble operations—Scale and Rotate—involve manipulation of a single parameter. For these, the marking menu turns into a control menu [75], so that dragging through the operation immediately increases the parameter. Scale (resize) is a common Assemble operation. Rotate is among Assemble Fastening operations, which also include Layer, Crop, and Blend. Some are performed through nested marking menus. Layer transformations enable users to position an element behind or in front of others. Blend manipulates opacity, enabling visual compositing when content overlaps.

Shift Perspective: Pan and Zoom

The *Shift Perspective* strategy is manifested by the Pan and Zoom operations, which manipulate a ZUI viewport onto the

	s_1	s_2	s_3	s_4	Total
Semester	Fall 2013	Spring 2014	Fall 2014	Spring 2015	
Students	319	296	326	306	1247
Curations	759	876	948	628	3211

Table 1: Number of students and curations per semester.

curation space across positions and scales. Pan is performed by dragging the background. Zoom is performed by mouse wheel or the familiar 2-finger pinch gesture. IdeaMâché’s zoom level spans 4 orders of magnitude. This is discretized into approximately 35 steps, each of which changes scale by a factor of ~ 1.3 . There is no pre-defined print resolution. This is intended to encourage users to compose content at different scales. IdeaMâché provides an overview to aid in navigating curation space when the user’s view is larger than the display.

Sketch and Write

The present IdeaMâché provides lightweight support for the *Sketch* and *Write* strategies, each of which constitutes a form of annotation. Each of these strategies is supported by a single operation. Sketch mode is activated through the curation space marking menu, which transforms the mouse cursor into a brush, used to draw strokes directly on the curation space. Color and brush size are adjustable. The Write strategy operation, constituted by text element create and edit, is also accessed via the curation space marking menu. Text elements are edited using an in-context toolbar, which contains buttons for manipulating font, color, and alignment.

Exhibit: Cloud Architecture

Storing, editing, and viewing content independent of a particular computer is a contemporary requirement for engaging users. The IdeaMâché cloud architecture enables saving, sharing, turning in, building on, and publishing curations as creative products. Each web curation is assigned a unique curation ID and permalink. Students use permalinks to *Exhibit* work to peers and turn in assignments to course instructors.

The cloud architecture is instrumental in research data collection. Our dataset of curations grows continuously. The cloud connects each curation creative product to user engagement logs, which capture authors’ creative processes, by recording invoked operations and their strategies. Each log record includes timestamp, curation ID, operation, and parameters.

FIELD STUDY METHODOLOGY

We report on an extended field study in which free-form web curation was incorporated into the undergraduate course, The Design Process: Creativity and Entrepreneurship (DPCE). The goal is to investigate supporting creative engagement with prior work, in ideation tasks, in a situated education context. We collaborated with course instructors in an iterative design research process. Our continuously evolving design intervention was based on the free-form web curation strategies, manifested in the IdeaMâché system and pedagogy.

Design Research Approach

Supporting design ideation through software and pedagogy in DPCE is a ‘wicked problem’ [79]. Design problems are ‘wicked’ when they involve complex, interlocking factors

that impact outcomes. There are too many potential solutions to enumerate. There is no way to deductively identify an optimal solution. Design research addresses wicked problems through iterative creation of artifacts: prototypes, products, services, and documentation [103]. By situating artifacts in a particular context of use, “*Design researchers can both discover effects and provide a template for bridging the general aspects of the theory.*” We observe that each semester-based university course instance constitutes a *one-shot* [79] opportunity to engage students, with a high stakes ethical responsibility to support valuable educational experience.

The Design Process: Creativity and Entrepreneurship

We evaluated free-form web curation’s support of engagement with prior work by observing creative products and processes in the DPCE field study. Learning objectives include becoming aware of innovation opportunities, developing skills in creative thinking and problem-solving, and learning to curate prior work to motivate the novelty of an innovation. The prior work students curate is expected to address needs, resources, and precedents, with emphasis on patents and journals, as sources of evidence. DPCE is a good fit for our design research because course objectives align with the research goal, to support creativity in ideation task contexts.

To discover effects of our design intervention, we performed a field study in DPCE over a series of four one-shot, single semester periods (see Table 1). The instructors were constant. Course pedagogy, outside free-form web curation, minimally evolved. There was natural environmental variation across student cohorts. The fields of the study’s student participants were diverse: architecture (27%) engineering (27%), agriculture (10%), liberal arts (10%), business (9%), general studies (7%), education (6%), science (3%), and veterinary medicine (2%). Gender was skewed: 37% female and 63% male.

DPCE students use IdeaMâché for ideation task assignments: e.g., *Imagine a Solution Curation* and *Soft Innovations*. The *Imagine a Solution Curation* assignment instructs students to conceptualize, design, explain, and reflect on a solution to a personal need in their life. Imagine a Solution curations, in practice, address everyday ideation activities similar to those found on Pinterest [55], such as weddings, workout routines, personal health, and redecorating. *Soft Innovation* (e.g. Figure 3,1) requires new designs for products and experiences.

While assignments were required, student participation in the study was voluntary. We asked students to consent to our confidentially gathering their creative products and tracking their creative engagement with IdeaMâché. We emphasized that study participation was optional and would not affect grades.

Evolving Design Intervention: ‘Show Me’ Feedback Loop

The strategies, system, and pedagogy evolved through the situated context of the study. In each semester, we presented an introductory lecture on free-form web curation, its strategies, and how to use IdeaMâché. The lecture included design principles, to teach students how to visually connect and differentiate elements in web curation. Around half of the lecture time presents strategies and principles, while the remaining half is a live demo. In s_1 and s_2 , we used PowerPoint.

strategy	operation	μ_1	σ_1	μ_2	σ_2	$W_{2,3}$	$p_{2,3}$	μ_3	σ_3	μ_4	σ_4	%+	μ	σ
Collect	Drag and Drop	36	1.1	45	1.5	346280	$< 10^{-9}$	68	6.7	63	2.4	73	53	2.1
Assemble	Position	140	5.9	150	6.5	362913	$< 10^{-5}$	240	17.0	280	36.0	99	200	9.0
Assemble	Scale	39	1.6	50	2.0	376665	$< 10^{-3}$	79	7.2	83	9.5	115	63	2.9
Assemble	Fastening	21	1.1	24	1.3	355925	$< 10^{-6}$	38	2.2	43	6.3	99	31	1.5
Shift Perspective	Pan	140	6.0	190	8.3	364888	$< 10^{-5}$	260	14.0	290	17.0	108	220	6.1
Shift Perspective	Zoom	36	2.4	73	4.0	388324	.017	96	4.9	100	5.7	190	77	2.2
Sketch		40	2.4	70	3.8	372266	$< 10^{-3}$	130	9.0	180	17.0	358	100	4.5
Write		23	0.9	32	1.2	389684	.023	39	2.6	34	1.5	47	32	0.9
Time Creating - per curation (hours)		1.36	0.05	1.52	0.05	326755	$< 10^{-13}$	2.37	0.07	2.23	0.10	64	1.87	0.03
Web Site Variety - ideation metric		11.4	0.42	13.6	0.41	330240	$< 10^{-13}$	20.0	0.63	20.7	0.88	82	16.0	0.30

Table 2: Table of analytics, per curation. For each semester of the study, we present mean (μ_s) and standard error (σ_s), followed by aggregates. We begin with engagement analytics for each strategy and its operations. The next engagement analytic shows how long students spent authoring. Last, we present Web Site Variety, which measures the diversity of sources that students *Collect* from. Wilcoxon rank-sum statistics measure differences in distributions between s_2 and s_3 , the ‘hinge’ semesters of the ‘Show Me’ Feedback Loop pedagogy. We observe significant increases for each analytic.

Starting in s_3 , our pedagogy evolved beyond ‘Tell Me’ to ‘Show Me’. We connected creative learning with creative teaching [53] by using free-form web curation, itself, to teach. Instead of presenting with slideware, we created a free-form curation about free-form curation [e.g., <https://ideamache.ecologylab.net/v/TAKIaq0008/>]. Class involved students in creating on-the-fly curations juxtaposing capabilities of a super hero and a patented technology. One example, juxtaposing Spider Man with bridge repair, curated patents and YouTube videos, along with comic images and sketching [<https://ideamache.ecologylab.net/v/nWy2q3C3rb/>].

The new pedagogy goes beyond describing to demonstrate free-form web curation. As our dataset grows, we incorporate exemplary student curations directly into pedagogy. This bootstraps a ‘Show Me’ Feedback Loop; prior student work impacts students and instructors in subsequent semesters.

FINDINGS

We gathered and analyzed data to see our design intervention’s impact on students’ creative engagement with prior work. We form a dataset of curation creative products. We compute analytics of engagement in curation processes. We observe an ecologically valid outcome in the DPCE course.

Curation Products Dataset and Examples

We began with all curation creative products saved in the cloud by DPCE students. To form a dataset, we filtered out insubstantial curations with fewer than 5 elements or 5 minutes of authoring. This resulted in a dataset of 3211 curations, authored by 1247 students (Table 1).

From the dataset, we present two exemplary free-form web curation products, which display creative engagement with prior work on the Soft Innovations ideation task. IdeaMâché’s lack of pre-defined resolution for print confounds rendering the curations in the medium of this paper. We encourage the reader to zoom into the figures in this PDF.

The *Cell Phone Charger* curation’s assemblage creates and instantiates an interesting design template (Figure 1). Structural repetition of design nodes—each with self-made text in the center, surrounded by a circle of readymade graphics—provides diagrammatic clarity. Consistent voicing and

positioning of self-made texts creates a distinctive non-linear narrative. The root node, bottom left in the overview, says, “Every person from ages 8 to 90 has felt the pain of having their phone die on them.” The next node says, “What’s even worse is when you have your charger and there is no power outlet to plug it into.” Readymade content sources are heterogeneous, e.g., product images, memes, tech blog content, artwork, schematics, and patent images. Each readymade element, including patent images, links back to its source.

In *Water Cleaning*, the overview shows two self-made rough circles, connected with lines, to form an exclamation mark morphology (Figure 3, bottom left). The top circle (not shown in detail), describes the problem, desertification and how society wastes water. The bottom one (Figure 3, main) builds on prior work precedents to develop solutions. Rough blue circles are labeled ‘puddle’, driving the water metaphor. A spatial template nests structures to continually go deeper into the problem and solutions. Figure 4 zooms in 2 levels of nesting, depicting how the proposed invention develops an emergent combination of thermal, filtering, and desalination techniques to solve the problem. We see how the student creatively engaged with readymade prior work content and the ideation task through the medium of free-form web curation.

Creative Process Engagement Analytics

We developed 3 kinds of data analytics, which quantify students’ creative engagement in free-form web curation. The first engagement analytics are based on how many times the constituent operations corresponding to each web curation strategy were performed by each student, as s/he created a free-form web curation using IdeaMâché. Another engagement analytic is based on the overall Time each student spent Creating each curation. The third type of analytic is the Web Site Variety ideation metric.

We present these analytics with a focused statistical analysis (Table 2). Many statistical analyses of this data are possible. We focused on student performance corresponding to the introduction of the ‘Show Me’ Feedback Loop into pedagogy, across the ‘hinge’ semesters, [$s_{2,3}$]. For each analytic, we used the Wilcoxon rank-sum test to test for differences between the s_2 and s_3 distributions. Wilcoxon is more rig-

ous than the t-test, because it does not assume that data is normally distributed [33, 45]. We found that each analytic grew in a statistically significant way. While not observing causality, we find that creative engagement grew significantly in correlation with ‘Show Me’ Feedback Loop pedagogy.

Fundamentally, we find that students performed all strategies, observed through engagement analytics for constituent operations. While Assemble Fastening operations and Write were performed least, basic Assemble operations—Pan, Position, Zoom, and Scale—were performed intensively. This means students took advantage of free-form web curation’s creative visual thinking Assemble strategy, despite the difference from prior modalities for curating prior work, such as traditional bibliographies and papers. Students also intensively invoked the Sketch strategy, another visual thinking modality.

The Time Creating analytic—how long students spent curating—rose by 64% over the course of the study and significantly across the ‘Show Me’ hinge semesters [s_{2,3}]. Spending longer on a creative task can mean increased engagement, rather than inefficiency. The correspondence of this analytic with the strategies and operations analytics and Web Site Variety indicates that increased Time Creating was substantially spent involved in creative processes.

Web Site Variety is an elemental ideation metric that measures the number of information sources Collected from, per curation [45]. Collecting from more websites tends to indicate more consideration and incorporation of diverse perspectives, contributing to more flexible and creative thinking. Web Site Variety nearly doubled across the course of the study and rose quite significantly across the ‘Show Me’ hinge. On average, in the aggregate, students curated from 16 different web sites, which seems substantial. Collected information sources can be exported as a conventional references list.

Ecologically Valid Outcome

In the semesters subsequent to the present field study, IdeaMâché developers omitted contacting DPCE instructors about continuing. We found that, instead, the instructors contacted us, at the start of semesters, to schedule our guest lecture. Free-form web curation has been naturalistically incorporated into course curriculum, as a means to stimulate creative engagement with prior work in the context of invention ideation task assignments. This incorporation represents an ecologically valid outcome, in the study’s situated context.

RELATED WORK

Prior systems in industry, academia, and research address engagement with prior work and other content. Prezi enables organizing content as presentations in zoomable space. Microsoft OneNote also enables spatial organization of content. Content in Prezi and OneNote functions visually, like content in PowerPoint, without being anchored to a source. EverNote enables clipping locations, but organizes them in linear lists. Zotero and BibDesk support maintaining collections of prior work references in a linear form.

In contrast, free-form web curation affords creating a new, visual ideation task context, in which users Collect image and

text clippings, Sketch amidst them, and spatially Assemble an integrated whole. Each clipping is augmented with contextual semantics that enable re-finding [40], which helps users derive value from the prior work they curate. Ongoing connections are sustained, between the contexts of prior work and the new context of the ideation task. To support writing papers, IdeaMâché enables linear BibTeX and HTML export of references derived from collected clippings.

Prior research systems also support clipping web content. Hunter Gatherer [86] supported clipping from ‘within web pages’ [86], enabling re-finding. The format of collections was the linear list. WebSummaries [23] supported structured information extraction into cards. PiggyBank enabled collecting metadata for a whole web page at a time [38]. Clui combined automatic metadata extraction with direct content clipping through predefined “rich objects” on web pages. Intermedia supported rich collecting of contextualized objects, each in a separate window [102]. None of these systems support organizing contextualized clippings, with sketching, in a free-form, multi-scale curation space context.

DISCUSSION

We connect findings with the strategies to develop implications for the design of web curation systems and education to support creative engagement with readymade content. The implications address multi-scale curation spaces, bootstrapping new media, teaching creative engagement with prior work, and social media platforms.

Multi-Scale Curation Spaces (Render-Independent)

Authoring tools, like Photoshop and Illustrator, provide ZUIs, but these are generally used in ways that assume fixed resolution rendering. This promotes developing detailed parts within wholes, but not multi-scale content organization, like the Eames’ Powers of Ten [24]. Recently, people have become accustomed to navigating multi-scale content through geographical browsing apps, such as Google Maps. Support for authoring conceptual curation spaces with these affordances, as contexts for ideation, likewise makes sense.

We found that even though people have limited experience with creating multi-scale content organization, they deeply engage. Typical DPCE students lack specialized backgrounds in graphic or information design. Yet, they organized information spatially, invoking the art-based Assemble strategy.

The analytics show invocation of all the free-form curation strategies. Intensive student engagement in single-scale spatial organization is evidenced by large Assemble and Shift Perspective operation analytics, Position (mean 200 times per curation) and Pan (mean 220) (Table 2). The Assemble and Shift Perspective operation analytics—Scale (mean 63) and Zoom (mean 77)—show that students also use changes of scale as a means to organize content.

At the same time, the Collect strategy analytic shows that students gathered many elements (mean 53). The Web Site Variety analytic shows they Collected from many sites (mean 16). We interpret this to mean that students were stimulated, by engagement in spatial organization, to Collect extensive and

diverse content. We also interpret that despite likely inexperience in organizing content in this new medium, students used scale, in the ZUI, as an Assemble technique, iteratively defining conceptual contexts of curation by creating content relationships that deal with the growing quantity of elements.

Bootstrapping: Use New Media to Teach New Media

Bootstrapping the use of new media for creative expression and learning is a chicken and egg problem. When people are unfamiliar with a paradigm, they may have trouble seeing how to use it. When we began offering the medium of free-form web curation to students, we used conventional slide-ware for pedagogy.

Then, spontaneously, we worked to incorporate this medium, itself, into our teaching. We used free-form web curation, instead of slideware, as the visual support for our presentations. We incorporated inspiring exemplary student work. We developed a paradigm to engage the class in a creative invention activity, based on the formula of first asking them for a super hero and an invention domain, then collaborating with them, to curate content juxtaposing these themes, on the fly. Across the ‘Show Me’ Feedback Loop hinge semesters [s_{2,3}], we observed significant increases in all measured creative process analytics. These findings motivate a prescription, to develop new media and then use them directly, in pedagogy, to teach.

Teaching Engagement with Prior Work

The digital age analogue of time-tested research in the library [94], collecting and recontextualizing prior work, is essential to scholarship in many fields [76, 16, 13] and also to innovation in industry [14, 8]. In their work on ideation task assignments, students intensively invoked the strategies of free-form web curation, while collecting extensive content. Some of them created striking displays of visual thinking. The instructors of the popular course, *The Design Process: Creativity and Entrepreneurship*, found the students’ engagement with prior work through free-form web curation adds sufficient value to their pedagogy, that they are continuing to incorporate this new medium into their curriculum. Beyond the scope of the present study, instructors and students in other fields, such as communication and human-computer interaction, have also found that free-form web curation adds value to education. We argue that this evidence motivates significant expansion of the scope of using free-form web curation—to engage, in creativity, students performing ideation tasks involving prior work—in diverse fields and institutions.

Social Media Web Curation Platforms

Web curation in social media is a huge market. Facebook alone claims nearly 2 billion users [25]. Twitter, Instagram, Tumblr, LinkedIn, Pinterest, and other curation platforms are also widely used. Each platform seeks to maximize user engagement. We argue simply that adding free-form web curation space to a user’s home page has the potential to engage her in creating a new context to represent her identity. For users who do engage in this way, their friends have the potential to engage as active readers, navigating the free-form curation spaces of their social networks.

CONCLUSION

We took a conceptual approach to designing human-computer interaction [41, 95]. We improvised—as if playing jazz [17, 11] or psychedelic music [34, 15, 28, 77]—in collecting and assembling prior approaches, practices, and principles, from across fields, in order to generate a set of creative strategies, which form the basis for a new theory of free-form curation.

Dourish and Harrison argue that the function of space is elevated to place when it serves as a context that supports situated human activity [32]. We apply Gertrude Stein’s aphorism: otherwise, “There is no there there.” [93] Likewise fundamental to the theory of free-form curation and its strategies are the roles of space and context in creating ‘there’. Space affords embodied assemblage of collected content. Space enables the creation of place through conceptualizing and realizing new contexts of exhibition, which, in turn, support and manifest the performance of ideation tasks and activities.

Invoking Rogers’ principles [80], we offer free-form curation, with its strategies, as HCI theory that is conceptual, critical, informative, explanatory, prescriptive, and generative. Free-form web curation, its constituent strategies—Collect, Assemble, Shift Perspective, Sketch, Write, and Exhibit—and our findings provide what Hook and Lowgren call strong concepts [36]. They motivate a dynamic gestalt of interaction design to support creative engagement with prior work—with potential to cut across particular use situations and application domains—residing on an abstraction level that can be realized in many different interfaces. These strong concepts can be further generalized, to cut across interaction modalities and channels of new media.

The Design Process: Creativity and Entrepreneurship is one situated course in the domain of invention in undergraduate education. *IdeaMâché* is one interactive system, which provides integrated support for free-form curation on the web. Visual, experiential, and quantitative data show that the system works to support creative engagement with found objects of prior work in the situation. We found that *IdeaMâché*’s zoomable user interface supported users in creating multi-scale curation space contexts, independent of rendering resolution, which, in turn, stimulated intensive and extensive curation of prior work. We found that using free-form web curation as new media, to teach free-form web curation, was effective for bootstrapping students’ creative engagement.

We observe that the web is a broad, pervasive channel for new media, with many possible situations. Free-form curation spaces have the potential to be utilized even more broadly, through new media channels and interaction modalities, such as mixed reality [6]. Strategies of free-form curation provide a theoretical basis for realizing a panoply of other interfaces, which may focus on supporting other situated contexts, domains, channels, media, and modalities.

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