Beyond Slideware: How a Free-form Presentation Medium Stimulates Free-form Thinking in the Classroom

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ABSTRACT

We investigate how presentation in a free-form medium stimulates free-form thinking and discussion in the classroom. Most classroom presentations utilize slideware (e.g. Power-Point). Yet, slides add intrusive segregations that obstruct the flow of information. In contrast, in a *free-form medium of presentation*, content is not separated into rigid slide compartments. Instead, it is visually arranged and transformed in a continuous space.

We develop a case study that investigates student experiences authoring, presenting, viewing, and discussing free-form presentations in a graduate seminar class. We analyze interviews, present a sampling of student presentations, and develop findings: free-form presentation stimulates free-form thinking, spontaneous discussion, and emergent ideation.

Author Keywords

Presentation; slideware; new media; education

ACM Classification Keywords

H.5 Information Interfaces and Presentation (e.g. HCI)

INTRODUCTION

This work investigates how classroom presentation in a free-form medium stimulates free-form thinking and discussion among students and the instructor. Presentation is a major component of classroom education. *Slideware* presentation media, such as PowerPoint, organize content into discrete elements, chained into linear sequences. Tufte criticizes PowerPoint as harmful to cognition because it, "Slices and dices evidence into arbitrary compartments" [35].

In contrast, in a *free-form medium of presentation*, content is not separated into rigid slide compartments. Instead, it is visually arranged and transformed in a continuous space. We
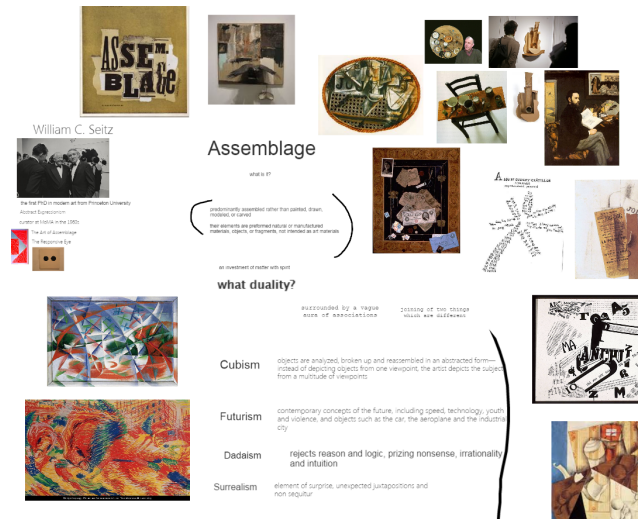

Figure 1. A multi-scale information composition, created and presented in class by a student instructor, on the Art of Assemblage, by William Seitz. View online: `http://ideamache.ecologylab.net/v/x2unOPmLEC/`

develop a case study investigating student experiences authoring, presenting, viewing, and discussing free-form presentations in a graduate seminar class.

Illich motivates the importance of free expression and thought in education [13]. Free-form thinking is spontaneous and unrestricted. We define *free-form thinking* as involving: (1) improvisational exploration of associations; (2) the emergence of new ideas, generated through building on previously known associations; (3) divergent wanderings to unexpected places; and (4) spontaneous synthesis of new understandings, relationships, and ideas.

To author free-form presentations, students engaged in web curation using the *IdeaMâché* system [14, 23]. The present research follows the conceptual model of the art world, where curation has become a mode of discourse involving the spatial arrangement of exhibition forms, using conceptual strategies of information systems [26]. Lupfer identifies the processes of *curation* as gather, assemble, annotate, and exhibit [23].

IdeaMâché supports curation and presentation in the medium of *information composition*, in which elements are gathered

from web pages, and assembled to form a visual semantic whole, which is intended to stimulate creative cognition of relationships [16]. The elements of curation are text, image, video, and sound clippings. The forms of annotations are text and sketch. Processes of curation are performed in a web browser. Curations are stored in the cloud, enabling authoring and presenting from anywhere.

We identify IdeaMâché's form of composition as a *free-form medium*, both of web curation—as users gather, assemble, annotate, and exhibit content—and of presentation, when they exhibit their curations in the classroom. Sketch annotation enables unconstrained markings to be incorporated in curations, while text annotation enables open exposition. Elements can be positioned anywhere relative to each other, as the user performs assemblage on a continuous 2½D canvas. They can be positioned, scaled, and rotated. A zoomable user interface enables organizing and presenting content at different levels of magnification, comprising a medium of *multi-scale information composition*. During authoring and presentation, the camera, can be positioned anywhere in the 2½D space.

Students in the graduate seminar course, *Curation and Ideation meet Social Media* (CISM), adopted IdeaMâché as a presentation tool (see Figure 1). The situated context of the classroom provides an ecologically valid environment for investigating the impact of free-form presentation on education. Graduate students in a seminar course are expected to engage in a high level of scholarship, asking critical questions and meaningfully contributing to class discussions.

Our research question investigates, *How does IdeaMâché's free-form medium of curation and presentation impact student and instructor experiences in the classroom?* We suspected that free-form presentation would have advantages, based on prior findings in the fields of visual thinking [2], art [4], and creative cognition [9].

We conducted semi-structured interviews to gain insight on the impact of using a free-form presentation medium in a discussion oriented course. We asked students to explain their experiences and processes as authors, presenters, and audience members. We analyzed interview data using grounded theory methods [34], forming four conceptual categories: *free-form assembly*, *curation and presentation practice*, *presentation improvisation*, and *as the audience*.

Our findings show how a free-form medium of presentation stimulates free-form thinking, improvisation, spontaneous discussion, and emergent ideation. Based on our findings, we discuss opportunities for advancing pedagogy and implications for the design of presentation tools for education.

RELATED WORK

Slideware
Slideware is a category of presentation support software which use slides to author and deliver presentations. A slide is set of information contained in a single view. Typically, a slide contains formatted text, an image or two, and may include video or audio media. During the performance of a presentation, a slideware deck shows a sequence of slides, which functions as a visual aid while the presenter speaks. Popular slideware includes Microsoft PowerPoint and Apple Keynote.

Tufte argues that the limitations of slideware result in mistakes [35]. The medium's ready-made bullet point lists promote confusion. When presenting, the relatively low resolution encourages using shorthand phrases instead of nuanced articulation. He berates PowerPoint as inappropriate for serious work after an analysis of templated Colombia Space Shuttle slides:

> [R]igid slide-by-slide hierarchies, indifferent to content, slice and dice the evidence into arbitrary compartments, producing an anti-narrative with choppy continuity.

In Tufte's view, the sequential and rigid slide-by-slide and line-by-line animations in PowerPoint create obnoxious transitions in a low-fidelity pigeonholed format. Instead of PowerPoint presentations, he prescribes using handouts. He rejects Miller's Magical Number Seven [24] as justification for the six words by six lines practice of PowerPoint. Instead, he suggests Miller's work motivates that building on *context* increases how many elements can simultaneously be understood.

Presentation Support Software
Prior research has addressed the shortcomings of slideware by transforming how the information presented and navigated. Criticisms of slideware has led researchers to explore ZUI media [11, 12, 21, 27], flexible ordering of slides [33], virtual blackboards [30], and multiple screens [5].

Zoomable user interfaces (ZUIs) enable the user to manually control the scale of the view, using continuous changes in scale as a fundamental interaction technique [3]. Good and Bederson developed CounterPoint, a ZUI presentation medium with paths that connect content for presentation [11]. They argued that ZUIs address problems with linear presentation software by providing a non-linear sequence during presentation delivery, maintaining multiple sequences through a presentation, and allowing different levels of details in context. They reported that CounterPoint provided better visual queues to prompt questions from their audience [12]. Fly [21] and Prezi [27] also implement ZUI presentation media, but the sequence of prepared views is linear, rather than hierarchical. Prior ZUI presentation tools use planned paths, rather than live navigation though pan and zoom. Rigid linear progression does not support improvisation, which enriches discussion oriented classes.

Spicer et al. addressed time constraints in presentation, creating a system that alters slide sequences based on importance [33]. NextSlidePlease automatically generates a slide sequence, including detailed slides for long presentations and overview slides when less time is available. In a study, participants re-created PowerPoint presentations, finding NextSlidePlease helped mange time constraints. We report on students skipping content in free-form presentations to manage time.

Lanir et al. observed differences in the dynamics and spontaneity between how presenters used slideware and black-

boards [19]. Presenters rarely returned to previous slides, but often drifted back and forth between ideas when using the blackboard. To support a larger visual space and enable non-linear presentations, researchers have developed systems which make use of multiple displays [20, 5]. MultiPresenter enables displaying two slides simultaneously, or one slide along with a finite space in which the presenter can clip content from any slide, arrange, and annotate [20]. Bligh and Coyle observed use of a multi-display presentation system in architecture education critiques [5]. They found creative benefits for both students and instructors as serendipitous discoveries emerged through drawings to elaborate ideas and unforeseen juxtapositions of content from the use of multiple displays. Free-form presentations juxtapose information in a continuous view, furthering this line of inquiry.

Curation and Appropriation
In the most broad sense, curation is a selective human process of choosing and combining items that provide value for a specific context [29]. Processes of curation creates wholes which have value beyond their individual elements. Curation enables generating and expressing ideas [16, 22]. People can consciously work with information as a means to generate and better articulate ideas [16]. For example, people use Pinterest to find and combine Pins from others, creating unique sets of image bookmarks [22] that address everyday, personal needs. This work explores free-form curation for authoring and delivering presentations in the classroom.

Popular digital curation tools, such as Pinterest and Tumblr, are designed for distributed viewership. In contrast, in-person presentations are visual aids for a live audience. Like slideware, Pinterest, Tumblr, and other curation tools use linear boards to store content [16], and so compartmentalize. In a free-form curation medium, however, content elements are visually transformed and arranged in a continuous space. Students in CISM used multi-scale information composition to create free-form presentations.

The process of curation is beneficial to personal learning because it provokes reflection and interpretation [37]. Webb et. al describe curation as an iterative, cyclic process, which helps people reflect, interpret, and construct relationships among ideas and content. We investigate curation as a means to author and exhibit in person presentations, in anticipation of the audience's needs.

Visual Thinking and Cognition
Presentations and their media are visual aids and support external cognition [31]. There are many approaches to describing how people perceive and utilize vision in cognition.

Arnheim argues that human processes of perception and thinking are difficult to separate [2]. Instead, thinking and perception both occur through the same cognitive mechanisms. For example, a person can both look (perceive) and close their eyes and imagine (think) to perform a number of operations: selection, abstraction, synthesis, combination, separation, and contextualization. These operations help people recognize and generate patterns from phenomena, helping form concepts for productive thinking.

Berger frames analysis through art, how we see paintings and other visual media [4]. He notes that children look and recognize before they speak. To *see*, one must purposefully choose to give something attention and attempt to recognize context. The meaning of an image depends on its context, that is what is seen immediately before, after, and along with it.

Finke explores visualization in the mind's eye as a means of invention [9]. Finke's experiments showed that people can imagine simple shapes and combine them to form emerging designs, e.g. the letters O and V can be manipulated to form an ice-cream cone. Experiments have shown the usefulness and novelty of designs started from images in the mind's eye. Spatial and visual cognition tends to use combinations and operations as creative stepping stones. The eventual solution is often not planned, but emerges from combinations who's value may only be recognized in hindsight. He calls these non-immediately useful combinations *pre-inventive structures*.

Tversky shows how visual communication is selective and relies on context from the world to enable practical interpretation [36]. For example, abstract maps can support navigating a city. She argues that visual communication involves telling a larger 'truth' by being selective and distorting details.

IDEAMÂCHÉ: FREE-FORM WEB CURATION
Students used the IdeaMâché system to curate media and perform presentations. IdeaMâché is designed to support expression and creativity online through a free-form medium of curation. The system's zoomable curation canvas supports gathering and assembling clippings, annotating with sketch and text, and a range of expressive visual and spatial transformations on all elements. Curated elements in IdeaMâché are represented as *rich clippings*. The system automatically captures each clipping's context in the web, as a metadata summary, using the type system developed by Qu et al. [28].

Zoomable Curation Canvas: Multi-Scale Assemblage
IdeaMâché provides a zoomable canvas for curating rich clippings and annotations. This supports organization of curated elements in the medium of *multi-scale information composition*, creating relationship which span across multiple levels, extending the tradition of the Eames' Powers of Ten [8].

IdeaMâché's zoomable curation canvas is a practically infinite 2½D space. Users are able to pan indefinitely and arrange elements of curation as close or far away as they like. This enables assemblage of content across position and scale.

In our study, students and the professor used IdeaMâché to assemble multi-scale curations. Subsequently, to perform a presentation, they moved the camera manually across and into their curations, to navigate among views (using the present IdeaMâché). The cognitive and neuromuscular effort involved in this navigation was non-trivial. Participants learned to navigate presentations effectively, despite this effort.

Annotation capabilities afford exposition, which involves labeling, explaining, expounding, connecting, and illustrating. IdeaMâché supports annotations in forms of text and sketch. Sketch annotations enable expression through drawing. The

roles of sketch annotations include textural, relational (e.g., arrows and boxes), literal (drawings of objects), and abstraction. Text annotations enable labeling the whole curation and subsets of elements. They thus support explicit categorizing, as well as expression through writing. Basic text editing, styling, and formatting are supported.

IdeaMâché supports visual transformation of clipping and annotation elements. The user can freely position, scale, rotate, layer, and blend elements. Through the use of visual transformations, users create engaging and emergent information compositions, juxtaposing concepts and telling stories.

STUDY: CURATION AND IDEATION MEET SOCIAL MEDIA

Curation and Ideation Meet Social Media (CISM) was a graduate seminar course taught during the Fall 2014. The course was open to students from a variety of disciplines, including, arts, humanities, social sciences, computer science, and engineering. Of the 12 students enrolled, 2 were undergraduate students. An additional 3 students audited the course. Thus, there were a total of 15 students, 12 male and 3 female.

The charter of CISM was to consider what curation is, how it serves human needs for engagement in ideation, and actual and potential involvement of social media. Students were asked to imagine future personal and social forms of curation and ideation, and roles for people and computing. They investigated contemporary curation and ideation practice, with reference to art contexts, empirical theories of creative cognition, graphical presentation, and social media.

In this seminar course, students were expected to participate at an advanced level. The course schedule included a comprehensive set of research readings, individual assignments, and a final project. Final projects involved curation, design, systems, information visualization, studies, and writing.

Participant Observer Methodology

We took a participant observer approach in our investigation. Participant observation is a thoroughly accepted method of ethnography, because it has been shown that all ethnographies inherently represent the perspectives of the ethnographer(s), as well as subjects [7]. In developing this research, our positions as researchers, students, and instructors overlap. Thus, we invoke a ethnographic methodology of first-person thick description, as advanced by practitioners such as Geertz [1].

We introduced IdeaMâché at the beginning of the semester of CISM. For the first class, the instructor, a co-author of this work, presented a course overview using IdeaMâché. In the next class, the *student instructor*, another co-author, presented a tutorial about how to use IdeaMâché. He also used IdeaMâché as the presentation medium.

We followed our evolving research protocol, as IdeaMâché has been used in various courses during various semesters. We ask students to participate in a study. We give students consent forms that allow us to gather their curations and ask them for interviews. We emphasize that participation in the study was optional and that it would not affect grades. In practice, in this stage, we are unsure as to if we will analyze a course's data and perform any further study.

Student Presentations

The instructor gave few presentations. Instead, student presentations on the course's primary readings led discussion and learning in class. The Research Literature Presentation assignment specified distilling and connecting significant research contributions from a set of readings, then contextualizing these vis-a-vis others across the curriculum and more broadly, in the fields of HCI, CSCW, and creative cognition. It further specified, "Make your slides (Powerpoint, Prezi, Sheets, ...) visually support and complement what you will say verbally." Of 22 total, 3 research literature presentations were given by the instructor, 4 by the student instructor, and 17 by other students. In practice, all of these research literature presentations used IdeaMâché. This was apparently influenced by the precedent set by the instructor and student instructor who gave the first four presentations with IdeaMâché.

Students also made presentations as part of two specified projects: (1) Curation: Analysis | Synthesis (individual), and (2) Final Project Cycle (team-based).

1. *Curation: Analysis | Synthesis* involved writing a short essay on a set of readings, authoring a curation, writing another short essay in response to the curation, and presenting and discussing the curation in class. This project was assigned twice, for different sets of readings. In regard to the medium of curation, the assignment specified: "IdeaMâché, Pinterest, Buzzfeed, Tumblr, or propose another platform and get [the instructor] to agree."

2. Presentations in the final project cycle were made once at the proposal stage, once in the middle, and once at the end. No specification was made about presentation medium.

As the end of the semester neared, we realized that almost all of the presentations in the course had been made with IdeaMâché. While we had anticipated some use from students, the level of adoption far exceeded our expectations. We sensed that an interesting educational process had been engaged and body of work created through presentations in the course. Thus, we decided to investigate further. Our main research question was: *How does IdeaMâché's free-form medium of curation and presentation impact student and instructor experiences in the classroom?*

Visual Data

We develop and present *visual data*. By this, we mean that the curation products stand as themselves, as aesthetic, conceptual, and communicative works, for direct interpretation by researchers. In this way, visual data sits alongside of qualitative and quantitative data, in mixed methods.

We collected students' free-form presentations, which were turned in as part of course assignments. In total, students and instructor created 44 free-form presentations using IdeaMâché. We present this significant body of work as a visual dataset, through an online spreadsheet [`http://goo.gl/O4qpTb`]. The spreadsheet features links to each of the 20 research literature and 24 Analysis | Synthesis presentation curations, for viewing in IdeaMâché. Free-form expression, visual explanation, and non-linear connections are clearly visible.

Student	Background	Gender
P1	PhD student. Works in industrial engineering and process management.	M
P2	PhD student with EE background. Works in same lab as P1.	M
P3	Part time Masters student. Software developer.	M
P4	Masters student graduating this semester with recently funded startup.	M
P5	PhD Student. Prior masters degree was in computer engineering. Now working in HCI.	F
P6	PhD Student in HCI. Works in same lab, but not on IdeaMâché.	M
P7	PhD Student in HCI. Works in same lab, but not on IdeaMâché. A co-author of this work.	M
P8	Undergraduate in Computer Science. IdeaMâché developer and co-author of this work.	F
P9	Undergraduate in Computer Science. IdeaMâché developer and co-author of this work.	M
P10	Student instructor, co-author of this work.	M

Table 1. We interviewed 10 of the 12 students registered for CISM.

Qualitative Data

We interviewed 10 of the 12 students (Table 1) who were enrolled in the course. Two of these were undergraduates. The instructor was not present for interviews. Semi-structured interviews ranged from 30 minutes to slightly over an hour. We recorded audio from each interview and later transcribed results. Two co-authors, who participated as students and tutors in CISM, led interviews.

Semi-structured interviews began with general questions about each student's background. We asked about experiences in authoring, presenting, and observing IdeaMâché use in class. We asked each student to contrast to prior experiences with slideware. For the first half of the interview, two researchers and an interviewee sat around a table without looking at the student's presentation. This allowed the participant to reflect from memory.

Next, we asked participants to login to IdeaMâché and show us their work. Gathered around a large display, we continued the dialogue, contextualized by the visual data, information compositions they had authored and used in presentations. This elicited participants to reflect on specific elements of their work, in the context of the course.

Using grounded theory methods [34], we investigated student experiences and perspectives. We initially transcribed four interviews and performed open coding. This produced more than 50 unique code labels, such as "macro shape", "great presenters" and "detours". Using these open codes, we formed and analyzed four conceptual categories: *free-form assembly*, *curation and presentation practice*, *presentation improvisation*, and *as the audience*. We recoded the first four interviews and coded the remaining six from this perspective. Using this framework, we also drew on prior literature to form theory and present findings.

FINDINGS

We report on findings from the student interviews. Students employed *Free-form Assembly* to create continuous structures of information. Classroom interactions helped foster a *Curation and Presentation Practice* which encouraged experimentation and helped students develop skills organizing and presenting. Students responded to questions and class discussions with *Presentation Improvisation*. Finally, they participated and recognized high quality work *As the Audience*.

Free-form Assembly

In their interviews, students explained that the free-form medium supported them in displaying and connecting a large amount of information. The medium of information composition of clippings imposes fewer constraints on the scale and position of information compared to those of slideware. Students gathered and assembled clippings, manipulating the position, scale, and other visual features of clippings and connected ideas with sketch and text annotations.

Students reported that multi-scale information composition was more effective for associating content elements, as compared to PowerPoint. Students were able to think about and express relationships though positioning clippings and using sketch annotations. They spatially grouped related clippings to form 'clumps'. P8 talks about her process of organizing her presentation.

> P8: Even when I was planning the presentation I was able to put thoughts down and arrange them in clumps and groups, rather than having them on different slides in a specific order and not allowing me to be more flexible with how I arranged everything.

P8's experience coincides with prior findings on cognitive processes that arise through curating and categorizing. Curation requires human qualitative reasoning and critical thinking [29]. Lakoff and Johnson [18] assert categorization is essentially an experimental process. In P8's view, the free-form medium of presentation supports her improvisation in thinking as she arranges clippings to test different relationships.

The visual and conceptual connectedness supported by free-form assembly extends beyond creating 'clumps' to the information composition as a whole. Through the use of scale and zoom, multi-scale information composition enables presenting relationships across levels of scale. We call this multi-scale organization. P9 highlights the holistic connectedness of the medium and how it contrasts with PowerPoint.

> P9: It feels like there's this place where you're putting everything and you're making [different clippings] bigger and smaller, but it all feels like its one big connected thing. Whereas PowerPoint feels like you've chopped up a lot of stuff.

P9's critique of PowerPoint, as "chopped up", mirrors Tufte's [35] assessment that slides segregate information. In comparison, free-form presentation extends cognition by connecting related items together in 'chunks' [24]. The zoomable and near-infinite canvas provides ample space for expressing and articulating complex relationships. P9 continues:

> P9: It's the difference between having a bunch of stuff on notecards and like having a bunch of stuff on a piece
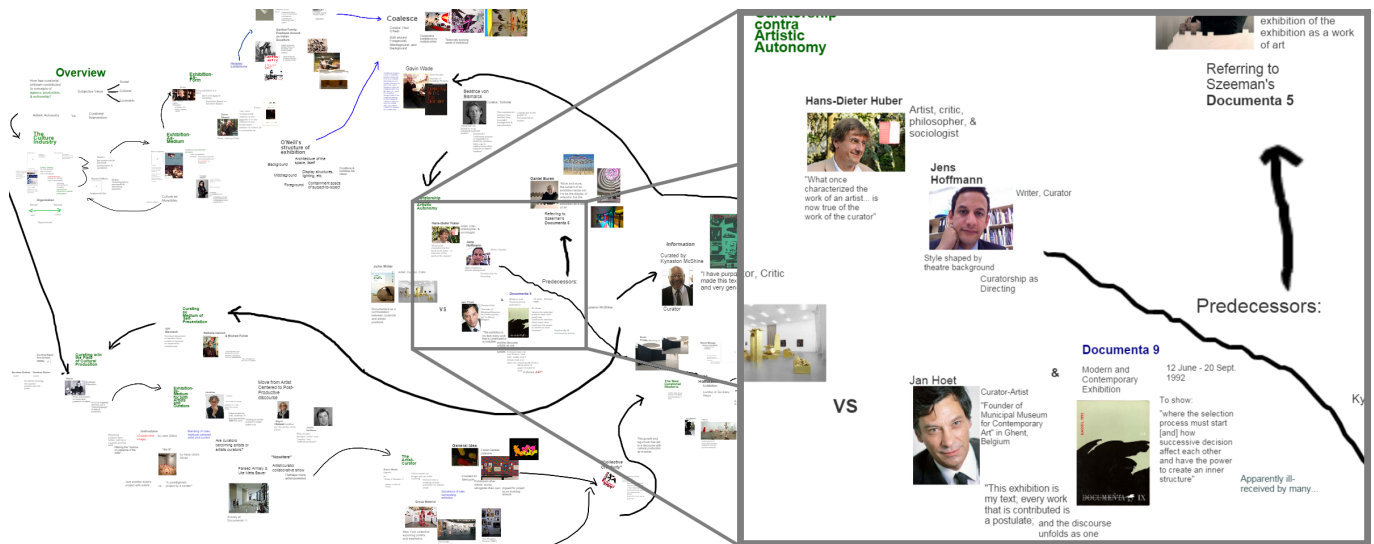
Figure 2. A student presentation, authored by *Trey Roady*, shown as a zoomed out view on the left with a detailed view of a specific area on the right. Viewable online: `http://ideamache.ecologylab.net/v/WclWQvZdTT/`.

of paper. [Information] on the notecards [is] all still in the same stack, but its all on different pieces of paper.

Alongside the use of position and scale, students used sketch annotations to articulate relationships between clippings and chunks of clippings (e.g., Figure 2). For example, P1 describes his use of sketching in his presentation, and P3 explains how sketches help structure information.

> P1: I use the drawing tool for arrows, to try and provide connections over how things flow through the structure, what path I'm taking through it so people can see where I'm going next. I also use those arrows to point back and show where new material points back to old material.

> P3: Well the nice thing about lines is that they direct your attention. ...Having lines, arrows, things like that, provide additional structure to the entire presentation.

> P7: It would be much harder to do [my presentation like this in] PowerPoint. [With PowerPoint], you have headers and section headers, and maybe sections. ...I think it's much harder to show the relationships and structure in Powerpoint.

The visual medium of presentation, that is, slideware or free-form, impacts a students ability to perform associational thinking. The medium may may help or hinder students connecting, conceptualizing, articulating, and understanding information. The free-form medium of multi-scale information composition helped students understand and create relationships among ideas.

Curation and Presentation Practice

The use of IdeaMâché was not required, but through the emergent culture of the classroom, it became the dominant tool used in the course. Most students did not have prior experience with IdeaMâché. However students felt comfortable using it, following the instructors' examples. Students learned the capabilities of the medium by participating in the class and experimenting outside.

P4 describes how seeing other students give their research literature presentations helped him learn the course expectations.

> P4: Seeing other presentations definitely helped me understand that I needed a little more ...prior work, specifically.

Students lead the majority (17 of 22 total) of research literature presentations. After seeing the professor, student instructor, and others' used IdeaMâché for course presentations, students grew comfortable in using it in lieu of slideware. While this was not required, they chose to use IdeaMâché for all research literature presentations and Curation: Analysis | Synthesis assignments. P3 saw the high level of student involvement as a way to make the course engaging. P2 notes his motivation for choosing to use IdeaMâché.

> P3: [CISM has] a different format of students actually engaging in lectures and presenting the lecture material.

> P2: It is to the professor's taste. The class is emphasizing IdeaMâché. ...[I thought], maybe it fits this class.

While students recognized the value of a free-form medium for presentation in the classroom, they saw PowerPoint as more formal. The look of IdeaMâché seemed informal to P3 and P4. One source for this perception may be the overwhelming popularity of slideware media. For contexts such as P4's start up investment and P6's conference presentations, an "executive look" can be crucial.

> P3: So [IdeaMâché] was overall an easier experience. It didn't look as professional, but ...[it is] more suited to brainstorming activities [and]...informal presentations.

> P4: Prezi is not a formal way of presenting at all. Microsoft nails it when it comes to formal presentation,

because of their enterprise roots. ...Prezi came into it late, compared to PowerPoint. ...We did try Prezi with a couple of investors, and trust me feedback wasn't really good. ...We went back to PowerPoint. You meet so many investors, but at the end of the presentation, you kind of gauge how the audience has understood it.

P6: I don't trust myself to fly by the seat of my pants [at internship and conference presentations]. Which, if I was doing something with IdeaMâché for those cases, I might be a little bit more worried if I still do a professional presentation with less structure.

While P4 was willing to try different presentation media, his audience did not receive it well. P6's view is that strong, non-improvised presentations are more appropriate for conference presentations. The context of CISM was more receptive of informal styles and alternate presentation media.

Students both observed presentations from class and browsed free-form presentations in IdeaMâché to familiarize themselves with how the medium could be used. They drew from examples to learn to better articulate ideas through information composition of clippings. While P4 emulates great work, P2 avoids pitfalls.

P4: I basically bookmark and keep [great work]....it gives you a better perspective of how you would use the tool. ...Presentations were much cleaner and much more precise and well designed than the first set.

P2: I liked the clear structure of IdeaMâché. ...There are a lot of freedoms in IdeaMâché ...if the structure is too complex, I feel like that might not be a good thing.

IdeaMâché's free-form medium requires ongoing critical thinking to effectively organize and structure information. P2 critiques overly complex design. P4 notes student presentations became better organized and more precise with practice.

Presentation Improvisation

Students describe their experience of presenting with IdeaMâché as planned, while leaving room for improvisation. By leveraging free-form presentation structures, presenters were able to manage audience attention. The free-form medium supported presenter improvisation, enabling them to embed details in presentations. without knowing if they would get covered. Students used the medium to help respond to spontaneous class discussion. In contrast, with typical slideware, presenters add in-depth details after the 'last' slide. P1 calls this strategy "hidden slides".

P1: You know that someone is going to ask you about this heavy data slide, but you don't have the time. What you'll do is put it at the end ...as a *hidden slide*. When you scroll through during presentation mode, it doesn't show up, but the moment that somebody asks, you can pop out, pull out the hidden slide and say, "here."

We contrast this interaction with how P3 answered a question.

P3: I was talking about social and cognitive causes ...and then the question came up about some additional

causes that were similar and touched on in the other paper. So I zoomed out from this area over here and refocused that. And then, after that, I simply went back.

The free-form medium enables connecting details to an overview, using scale. Connected concepts are positioned in lateral relationships. Students, such as P2 and P3, panned and zoomed through these spatial structures, taking on the role of a discussion conductor, who guides the attention of the audience to cover the main points of a presentation, while supporting free-form thought.

P3 compares free-form presentation to "choose your own adventure" games, in reference to a classic genre of non-linear children's books (e.g. [25]). In his presentation, P3 included more details than he expected to present.

P3: I covered about 75 percent of [my presentation], but there was another 25. ...And then, I just covered whatever was appropriate during the presentation and whatever direction the questions went or wherever the interest was. It's kind of like a *choose your own adventure*.

...You have the content that you expect to cover that you are intending to cover ...but there were all these possibilities that I could see branching off.

P2: [Panning and zooming is] a way to guide their attention. ...Conceptually I think I built some smooth connections around these digital objects.

To P6, guiding audience attention is important. He describes a tradeoff between slideware and free-form presentation:

P6: With a Powerpoint, ...it's easier to make sure they don't see what's coming up next. So I have more control over the experience. Whereas with this, it is really hard for me to keep people from looking ahead, which I may or may not want depending on how I want to present the material. ...I feel like it helps me fluidly focus on different ideas during the presentation. I can bring in ...different media from different places which ...sort of facilitates discussion during the presentation.

Free-form presentation, while offering less total control, helps the audience look ahead, stimulating spontaneous discussion. P6 also highlights heterogeneous kinds of media that can be curated. His presentations juxtaposed scholarly media with entertaining and relevant videos.

Manipulating precise views over a free-form presentation can be challenging.

P2: part of [IdeaMâché's] worth is that its flexible, but when I present, I'm not be very good at controlling IdeaMâché. Sometimes ...I zoom out too fast. So, maybe the audience will be a little bit confused.

While free-form presentation is flexible, supporting spontaneous discussion, transitioning from view to view smoothly can be difficult.

As the Audience

Students from CISM were presenters and audience members. We asked students to characterize their experience as audience members. In general, presentations were understood and stimulated class discussion. Certain presentations (see Figure 2) stood out to students as beautiful and effective.

In some cases, students produced disorderly presentations. This may have been due to time limitations, unfamiliarity with the medium, or design skills. A free-form medium is not a panacea. Without proper design, presentations can appear muddled. P1 suggests a technique of 'signposts' for visualizing themes to help mark progression through a presentation.

> P1: Some people had difficulties knowing what they wanted to say next, what they wanted to say about a topic, they had to explore the space when they were up there. ...A couple of people did not know exactly [what came next] if they didn't signpost it themselves.

As an audience member, P6 recalls being "entranced" by the visual material, rather than the presentation.

> P6: I remember specifically [in one] that I found it hard to focus on what he was currently talking about ...I was sort of entranced by [the content].

Students noticed high quality work. The attributes of strong work included clear relationships among elements, creative presentation, and visually distinct arrangement.

> P8: There were a couple that were really good. ...I thought that one showed the relationships between things very well. It was a creative way to set it up. [I]t got the point across that he was trying to say.

Overall, spontaneous discussion in CISM added depth and emergent ideas. P4 notes how free-form presentations stimulated questions how material was related, which P9 and P8 saw answered with new ideas for meaningful connections.

> P4: [Free-form presentation] helps you question how things are related; and the more open a presentation is, the more questions you get.

> P9: [Some were] not really relevant ...But, then again, there were a lot of really good [discussions] ...[that] brought a lot of information into the class.

> P8: People would bring up related papers or related experiments to compare and contrast and go more in depth.

P10 describes his presentations as unscripted, relying on the content of the presentation to help draw out discussion. As P7 notes, in CISM, questions from presenters stimulated discussion that produced little-c creative ideation.

> P10: I feel like it's extremely appropriate for everyone to get out the most information and learning they can out of a presentation whether or not the presenter was prepared for it. ...I hadn't rehearsed this - I didn't have any script I was going off of. ...I would ask people, "Does anyone have any thoughts about this?" ...[I'm] trying to share the wealth of knowledge of all the students in the classroom.

> P7: Often when the presenter asks, initially there's a period of silence. Then someone says something, some initial thought. ...In that case, almost all [students] will respond. People collectively come together and answer.

While P7 and P9 note some tangents, by and large, presentations informed CISM participants and stimulated engaging discussions.

IMPLICATIONS FOR DESIGN

We develop implications of design for pedagogy and the design of presentation tools to support creativity. Our findings show that a free-form presentation medium stimulates associational thinking, improvisation, and spontaneous discussion.

Continuous Views Connect Ideas

We observed that students associated ideas and concepts in new ways. They created their own perspectives, extended their understanding, and connected ideas. Burleson argues creative learning tools should enable showing multiple points of views to foster the imagination [6]. Panning and zooming the ZUI canvas can create an infinite number of viewpoints. During a presentation, students create and encounter new and emergent views. Contrast this with the finite number of n slides in a PowerPoint presentation. Tufte prefers high fidelity paper to slideware because its form is continuous, rather than 'sliced and diced' [35]. P9 remarked that, with free-form presentation, *It feels like you're still in the same conceptual space ... [instead of PowerPoint's] flipping through all these different images.* Continuous views better connect ideas.

We observe that imposing predefined frames on a presentation medium 'slices and dices' information. This is true not only of slideware, but also with ZUI's like CounterPoint [12] and Prezi [27]. CounterPoint uses a slide metaphor, but allows slides to be freely arranged. However, information must still be contained in rigid rectangular frames. In the same way, Prezi requires information to be placed within rectangular frames to enable presentation transitions. While these systems possess advantages over PowerPoint, such as smooth transitions and better connected content, the frames separate content, in comparison with IdeaMâché's free-form medium.

The free-form medium enabled showing multiple perspectives through continuous and non-linear assembly and annotation of information. Students used the medium to experiment with relationships among elements. P3 connected ideas by arranging clippings and associating them with arrows, *"Having lines, arrows, things like that, provide additional structure."* These implicit structures and free-form assembly of clippings enable associational thinking.

Promote Improvisation

In CISM and other discussion driven courses, improvisation is crucial to education. Fisher and Amabile propose a model for improvisational creativity: *"In improvisational creativity, a large number of well-learned facts and routines that are readily available, accessible, and flexibly organized are important to prior action [10]."* Improvisational creativity relies on a 'vocabulary' of small chunks of actions, for example,

'licks' in jazz. Encouraging experimentation, accepting mistakes, and promoting action facilitates improvisational creativity.

Students assembled their own vocabularies for improvisation using clippings. In CISM, students gathered their vocabularies from prior research and recent news. Through the free-form medium of information composition, students organized their clippings into flexible visual structures. Students relied on their prepared vocabularies to present.

As the course culture matured, students became more adept at preparing for improvisation. As P4 saw it "*[presentations were] much more precise and well designed [the second time around] than the first set.*" P1 developed a technique he called 'signposts'. A signpost is a large clipping which denotes a major theme in the presentation. He used these signposts to direct audience attention and help him navigate the ZUI to dynamically react to questions. P1 and P3 both included information in their presentation that they planned on skipping over, unless asked about specifically. The informality created by the improvisational presentation style encouraged spontaneous discussion, learning, and experimentation. As Burleson notes, a constructionist approach to education favors student intuition over formal instruction [6]. Students used the flexible structures and self-created vocabularies to improvise as presenters. As P3 described it, he guided his presentations in a kind of 'choose your own adventure' style.

Enable Scripted Presentation with Improvisation
Students' free-form presentations were unscripted. For classrooms, improvisation and discussion was seen as appropriate. However, scripted presentations with an "executive look" are commonly expected. P2 expressed anxiety about panning and zooming IdeaMâché during presentations. In formal presentations, P6 was leery of poor outcomes from unscripted presentation. The risk of potential failure can be exacerbated by the high cognitive load needed while presenting. In the present version of *IdeaMâché*, users had to manually control pan and zoom while presenting. The implication for design is that new free-form curation media should enable scripted presentation, which automates panning and zooming, while also allowing for improvisation.

Stimulate Creative Ideation: Emergence
Creative ideation, learning, and self-actualization are synergistically connected [6]. In Kaufman's et al.'s model of creativity, personal insight is a necessary precursor to more eminent creative products [15]. Thus, personal insight and learning initially constitute *mini-c* creativity. When it is externally expressed and communicated, these insights become *little-c*, shared everyday innovations. They label innovation that reaches the professional leves as *Pro-C* creativity, while using *Big-C* creativity for innovations that impact society. Authoring free-form presentations in CISM stimulated mini-c ideation. These mini-c ideas took on little-c creative function, as students shared them through class discussions, papers, and final projects. Inasmuch as students publish ideas developed through the course, these ideas developed through free-form presentation take on a Pro-C role. For example, P5

crystalized her thesis topic through authoring and presenting in CISM using the free-form medium. This paper is another example of Pro-C creativity developed through free-form curation and presentation.

A free-form medium provides opportunities for creative ideation. Panning and zooming an information composition presents curation elements in a series of contexts. Presenters and audience members are stimulated to reflect on relationships among these combinations of clippings and annotations. Finke argues that intermediate combinations, which do not immediately appear useful, function as precursors to useful ideas; these are known as *preinventive structures* [9]. Free-form presentations, by presenting many views, display perspectives that can inspire ideation. By seeing objects in new contexts, presenter and audience engage in visual thinking via gestalt experimental categories [18], contexualized perception [2], and relational and artistic meaning making [4].

P5 developed a presentation on how biracial identities, such as her own, become impinged on by prevailing either-or mentalities on race. She initially curated clippings, such as one of the Blue Man Group, simply because she liked them. In practice, these functioned as preinventive structures, which stimulated emergent ideation. For example, *P5: I pulled different pieces together . . . I talked about the Blue Man Group. . . Blue is a natural color, the color of the sky and the ocean. As far as skin tone, it has no connotation or associations with race or emotion.* Through recontextualization in the contexts of the composition as a whole and of her presentation in class, P5's Blue Man Group clipping came to stand for blended identity, extending beyond expected categories of race.

CONCLUSION
Free-form curation provides preinventive structures, which, through free-form presentation, stimulate free-form thinking, mini-c and greater creativity, and emergent ideation in the classroom. Krueger uses *responsive environment* to describe an iterative series of contexts, established by an interactive computing system, and transformed by participants' actions through the interface [17]. We found that in the classroom, the presenter continuously interprets the needs of the class, expressed through discussion, in response to a series of contextualizing views of a multi-scale information composition. The presenter responds iteratively by speaking and revising the view. The rest of the class iteratively responds by speaking. Free-form thinking is stimulated. Ideation happens. The use of IdeaMâché thus constituted a responsive environment of free-form presentation and spontaneous discussion.

Students in CISM curated clippings and annotations, forming preinventive structures that stimulated free-form thinking. In presenting, they explored associations improvisationally, presenting a series of unscripted contexts. Students connected and recontextualized information from research literature, social media, and their own experiences. These recontextualizations frequently attained mini-c, individual, and little-c, class-wide, levels. Moving beyond the classroom, contributing to theses and to publications such as this, ideation stimulated by the free-form medium of curation and presentation subsequently attains the level of Pro-C creativity.

Presentations that involve improvisation better support learning and ideation than scripted monologues. While slideware "slices and dices" information into fixed slides, free-form curation provides a continuous space for connecting ideas. The continuous space better supports experimental categorization [18] in the authoring process. In class, the series of contexts provides diverse views, which help overcome fixation [32]. The ability to improvise with pan and zoom in presentations creates an infinite space of potential perspectives, producing new opportunities for ideation. Unscripted presentations can better respond to situated emergent contexts in the classroom. They can effectively build on emergent ideas that arise through spontaneous discussion.

Our investigation takes a participant observer approach. The researchers were involved in the course and in the design and development of IdeaMâché. Co-authors of this paper served as active participants, as creators, exemplars, teachers, developers and observers. We thus instantiate the first-person tradition of ethnography in HCI. Students and researchers spontaneously participated in a process of creative ideation. We iteratively created a body of scholarly and artistic work, which in turn, through free-form presentation, stimulated free-form thinking and improvisational discussion.

We were surprised by students' level of adoption of multi-scale information composition, by the quality of their presentations. We invite the reader to experience the wonderful body of work created by the participants of CISM [`http://goo.gl/O4qpTb`]. Free-form thinking and presentation are critical for the current and next generation of thinkers who continuously co-create and transform the world. We identify IdeaMâché's free-form medium of curation and presentation, multi-scale information composition, as a means for stimulating spontaneity and creative ideation in a range of courses throughout STEM, arts, and humanities education at secondary school and university levels.

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