Weblines: Enabling the Social Transfer of Web Search Expertise using User-Generated Short-form Timelines

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Abstract: Web search encompasses more than fact retrieval; it is a primary entry point for learning. Exploratory search tasks are attempts at such learning and require cognitive, strategic, and interpretive work from the user. The pathways of such searches are likewise complex and nuanced. The present study attempts to enable the human work that goes into conducting exploratory searches to be efficiently captured and transmitted to other learners. By this method, web search expertise can transfer socially and implicitly between users instead of developing individually or through directed learning. The system we deployed uses an existing metaphor, the timeline, to structure insights from searches. We refer to these semantically meaningful representations as 'weblines'. We deployed a live system to 81 users in three user populations. The resulting weblines were delineated into four types. Successful weblines were those that participants used to iteratively reflect upon the insights of their searches.

Introduction and Motivation

Web search has emerged as a primary entry point to acquiring, confirming, and analyzing knowledge. The study of search has grown to encompass more than looking up discrete facts (e.g. In what year was the San Francisco fire?) and into the informal and formal learning of complex topics (e.g. Why did my local public swimming pool close and what can be done about it?).

Moving beyond the traversal of digital libraries and into general knowledge acquisition it is a skill that crosses the boundaries between formal and informal learning environments and across cultural and socioeconomic strata. While we tend to think of web search as 'information retrieval' rather than learning, much learning in information societies takes place during web search.

Information-processing theory posits that the formal mental operations required to conduct purposeful and effective searches (e.g. as required to define abstract keywords) emerge at the corresponding developmental stage. We view the logical steps in web search as a partial and abstracted representation of the user's cognitive process. By representing such processes we allow them to be transferred between participants via cognitive apprenticeship, a process by which learners can model accurate problem-solving skills by inspecting the cognitive processes of instructors (Collins 1987).

Insights: The Products of Exploratory Web Search

Researchers are actively attempting to unpack search into different types that vary in complexity. An oft-cited theory is the distinction between lookup, learning, and investigation tasks (Marchionini, 2006) (see Figure 1) while another attempts to use navigation characteristics such as 'search moves' to describe the complexity of the search task (Aula, Russell, 2008).

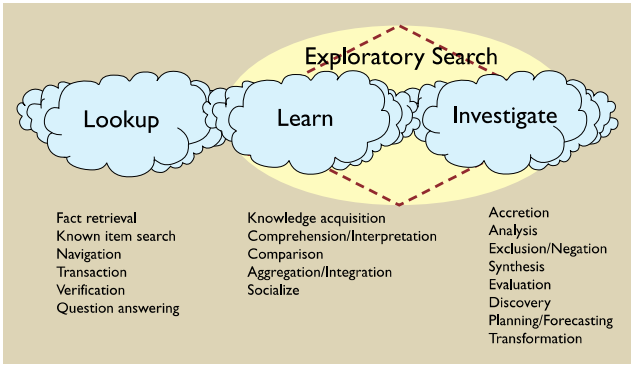


Figure 1. Web search is a broad area. The research community is growing to consider Exploratory search as being of utmost importance as it relates to higher-order tasks and processes. The results from such searches are ostensibly of greater value to the searcher and others (from (Marchionini, 2006)).

Improving system and user efficacy for exploratory search tasks has emerged as a paramount problem of human-information interaction research (Marchionini, 2006). Currently, exploratory search success depends

largely on the cognitive and interpretive work of the user rather than retrieval algorithms. This human work increases the potential value of the results to the searcher and potentially to others. That work also contains cognitive processes and interpretations that are likely to be instructive to other learners about the topic at hand or the search process itself.

The results of exploratory searches are also different from those of lookup tasks because the insights gained often come from connections found across multiple webpages. This leads to a problem the present work aims to solve: how can we support users to share a series of related URLs that led to the insight in question?

For lookup tasks, the problem of sharing results has been largely solved using 'link-sharing' mechanisms common to social networking status updates and micro-blogging where a single URL is qualified with an optional textual description or conclusion. However, the problem is not solved for more complex and multi-step queries where multiple pages and queries are necessary to qualify and communicate the insight. As Hamming was paraphrased in (Gersh, *et al*, 2006), "the purpose of exploratory search is insight, not data." (The original quote was "The purpose of computing is insight, not numbers.")

We refer to the results of a complex search as 'insights'. Insights are the result of "a story implied by relationships among discovered information items" (Gersh, *et al*, 2006). In this study we present work conducted to capture and represent the insights from complex search for later individual use as well as the social transmission of knowledge. We narrowed our focus to results from news-related searches as these encompass common research methods as well as being of social interest.

After first motivating the study of sharing insights, we present a summary of related research on the topic. This is followed by a description of our iterative, user-centered design process that draws upon principles from micro-blogging, print media, and social media. We present results using the deployed system with 81 unique users and 195 shared insights. We studied the nature of these insights and what differentiates them. Our results have implications for the study of learning technologies concerning web search expertise and knowledge-sharing systems within classrooms and organizations.

Related Work

A comprehensive and nuanced understanding of the development of search expertise (and "online reading") is emerging in the literature (Leu, Zawilinksi, 2007). Formulating queries is complex task due to its reliance upon abstraction, vocabulary, domain knowledge, and grammar. Despite this complexity, query formulation is often the focus of explicit instruction because it is so central to Web search practice (Lazonder, 2003).

Prior work studying the habits and behaviors of students of various ages using the Internet in directed or self-directed tasks have associated novice searchers with issuing vague queries (Bilal, 2000), focusing on surface site features (Coiro, 2003), and limited confidence about and awareness of Web resources (Druin, 2010).

Numerous search curricula have been proposed though none are yet established as standards. Instructional guidelines have been proposed for teaching search skills and creating relevant learning environments as reviewed in (Lazonder, 2003). These approaches have focused on direct learning, not social, implicit learning.

The concept of imitating a skilled practitioner is perhaps the oldest and most natural form of social learning (Lave, Wenger, 1991). However, it is not clear if imitating an expert's queries or navigational choices directly enhances a searcher's skill set. Rather, it is the process underlying a search that is useful to imitate. This is because information needs vary from moment to moment, making the user's conceptual model of search paramount. In postulating that these processes may be socially transferred, we draw upon cognitive apprenticeship (Collins, 1987), which posits that learners can imitate experts by deriving components of their thought processes, not just their behavior.

Sharing the Web Search Process with Others

Another branch of research in this area has been on how search processes can be represented and shared. Indeed, Vannevar Bush conceptualized "trailblazers" whose primary function in society would be to establish paths through hypertext collections for the purpose of serving future searchers (Bush, 1945). High information-density visualizations of web navigation processes have traditionally been used to study information-seeking behavior.

The work of Lin, *et al*, on visualizing search processes (Lin, 1991) (see Figure 3) led to representations like PadPrints (Hightower, *et al*, 1998) for search behavior analysis and navigation flow maps (Lin, Tsai, 2005) for enabling search instructors to understand student search behavior.

Academics have also used graphical representations of search processes for learning purposes. Twidale, *et al*, attempted to apply such representations to support collaborative search explicitly for the purpose of improving expertise (rather than improving instruction) in searching structured digital libraries with Ariadne (Twidale, 2005). These and related systems are useful for instructors and curious searchers in formal learning environments. However, they require learners be explicitly interested in improving their search expertise. We propose drawing learners into the search process of another expert through a compelling narrative.

A number of commercial applications are enable publishing and sharing of navigation histories or a collection of links about a topic. They include TrailFire.com (now defunct), PearlTrees.com, and Google Bookmarks. As far as we have seen, they have not differed significantly from any prior academic projects.

Sharing the Results from Search and Analysis

Gersh, *et al*, supports the sharing of insights in the intelligence community (Gersh, 2006). Their tools aim to share "chains of data, evidence, hypotheses, and other constructs, in which a collection of lower-level information supports a statement (hypothetical or real) at some higher level of organization or abstraction".

What remains understudied is how the results from exploratory search can be structured in a lightweight and flexible manner that can be shared to aid social learning and lead to well-acknowledged search expertise exemplars and practices. Such a representation could improve knowledge-transfer within organizations, classrooms, or in public.

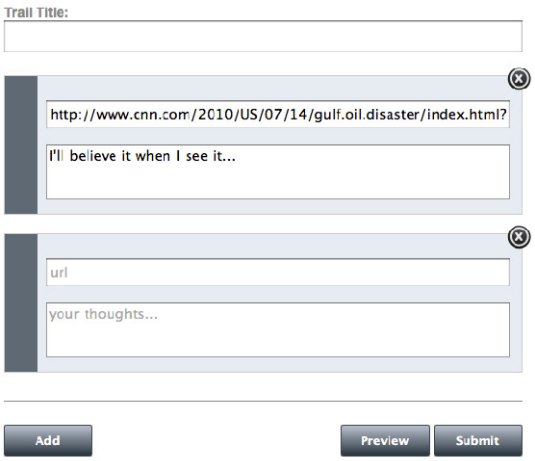
A User-centered Design Process for a Tool to Share Web-based Insights

We set out to design a system that allows users to create a single representation from a small collection of URLs that result from a complex or exploratory search. We expected the representation to consist of four components: (1) a collection of URLs, (2) the relevant portion of each URL, (3) a semantically cohesive title or meta-description, and (4) a visual representation that makes this collection easily and quickly understandable.

Though the system is designed to support social learning of web search expertise, its ostensible goal was to share insights from exploratory web search. This section describes how the final system, LineHive.com, evolved through three rounds of user testing. The final design (see Figure 4b) uses an embeddable timeline representation to aid in describing a narrative and constrains the set to ensure all items are always visible simultaneously.

Connecting a Collection of Related URLs

Based on existing practices, the initial design approach was to allow a user to declare a collection of individual URLs in a manner that closely resembles existing link-sharing practices on micro-blogging services and social networks. Such practices support sharing results from lookup tasks, *i.e.*, a single URL and an optional user-generated caption. A title was added to allow the user to describe the collection, as shown in Figure 2.



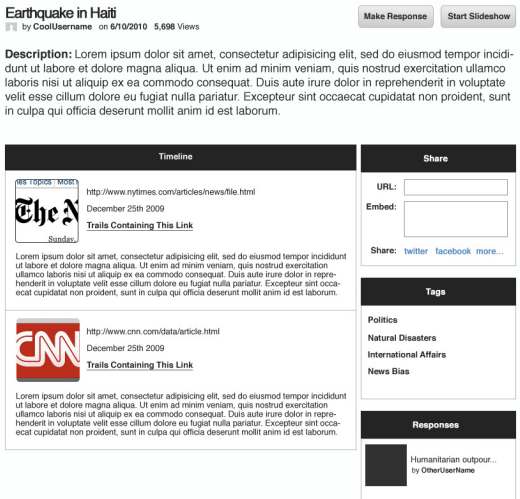


Figure 2. Our initial approach allowed a user to define a title for a collection of URLs. Each URL was then added manually with a subtitle (labeled, "your thoughts…").

Figure 3. Our second iteration was a weblog view of a URL sequence. A rich description is included to support writing of a narrative, an 'embed code' field is included.

We asked three university students to create a collection of links using a medium-fidelity prototype of this system. The primary feedback we received was that commentary or a preface was necessary to describe the sequence of URLs. This initial prototype did not feel sufficiently easy to create and share. We noted how disjointed the items were from one another. We reflected upon how, in contrast, user-generated blog posts can contain multiple URLs yet still feel cohesive because a narrative connects them.

A Weblog View of a URL Collection

Figure 3 depicts the next iteration of the interface, which added a description under the title for narrative or explanatory text. The items were laid out as individual, short weblog entries, using a well-known online metaphor (*i.e.* blogs). We also added support for reader comments and related 'trails' (as they were then called).

To support the transfer of these trails as units, we added support for embedding them as an HTML widget (as is popular with YouTube videos).

Our team conducted informal feedback sessions with several adults and found a number of problems. The description field would likely prompt users to type information, making creation prohibitively laborious. The sequence or relationship between individual URLs in the collection had to be described textually by the author, resulting in even more text. This extra information would make it time-consuming to read and result in a reduced ability to be treated as a single structural unit and theme. Similarly, the vertical scrolling required to view more than two links meant the reader would never see the sequence in its entirety.

Our approach to remedy these issues was to employ a metaphor that would constrain the URL collections but enable fast inference of the relationship between each URL. This would reduce the amount of text required to be written.

Weblines: Using Timelines to Represent Insights from Web Navigation

Using timelines was an attempt to turn the URL collection into a URL *sequence*. The timeline is a well-understood metaphor that includes its own narrative: setting, apex, and resolution along a temporal dimension with any units. Timelines also connote a story rather than simply a logical collection; timelines are used to outline stories and they make regular of use of thumbnails, a useful visual element for digital media.

We refer to these timelines as *weblines* because they are timelines about web traversals meant to guide another's sense-making process on the web. That is, individual items must link to URLs, they cannot contain arbitrary information or events. This constrains what weblines can be used to express but enable readers to interrogate and re-interpret the source URLs.

Following Western tradition, the timeline is presented horizontally. This was also done to ensure the sequence felt like and could be embedded in other webpages more easily. The authoring experience required the author to add a URL for the webpage and one for the thumbnail. User-defined subtitles of each URL appear on mouseover as tooltips when the user's mouse hovers atop the thumbnail.

There are two potential dates to use for each item in a webline: publish date and user access date. Our initial implementation ignores the latter and attempts to parse the former from the source URL but makes it user-configurable.

The result was a highly visual sequence of images meant to tell the story using the imagery alone. In feedback using a high-fidelity prototype with five users, we found it difficult to create a sequence whose images alone would be communicative. Figure 4a shows what would be displayed if you viewed one webline alone. The user's mouse is hovering on the third item from the left. Figure 4b shows a webline embedded in another webpage (without reader comments and metadata).

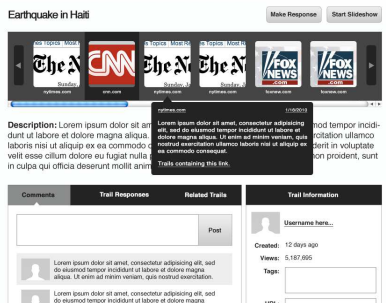


Figure 4a. A webpage dedicated to displaying a single webline. Thumbnails depict the items in the collection of URLs and a textual description describes the narrative. The reader here is hovering their mouse atop a thumbnail to reveal the subtitle.

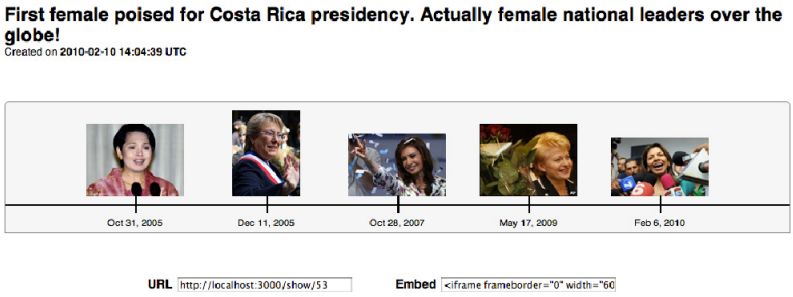


Figure 4b. A webline embedded in another webpage hides the narrative description.

Though the initial impression of the page was less loquacious and more visual than the previous iteration, hiding the captions in tooltips meant the users co-opted the description fields to describe the narrative, again creating an abundance of text. The distinction between webline title and item description prompted users to type short titles (3-7 words) and very long descriptions. The goal for the next revision was to make the narrative immediately apparent by complementing the thumbnails with text and reducing reliance on the description field.

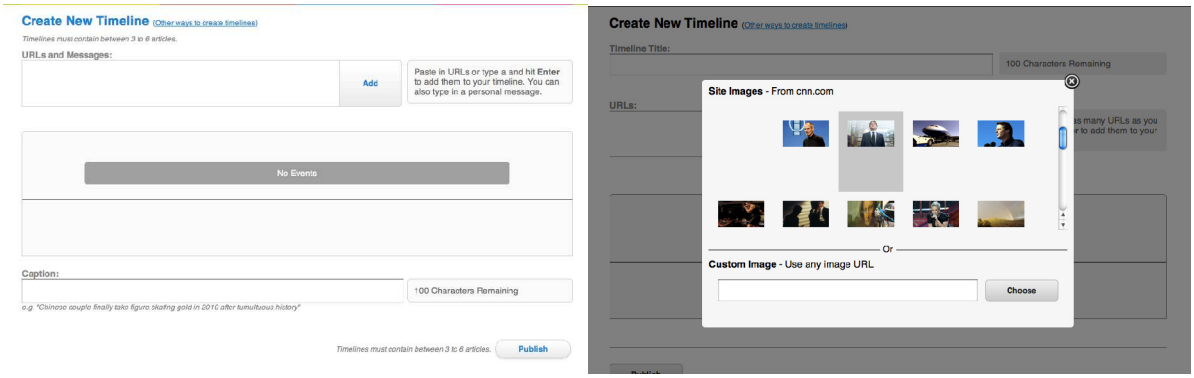


Figure 5a. The WYSIWYG authoring interface has essentially two elements: a textbox to paste URLs into and the resulting timeline below it. A single box enables the author to add items to the webline. As dates are changed of individual items, their order animates to the new sequence.

Figure 5b. After entering an item URL, the user can elect to refine the choice of a representative thumbnail. A list of thumbnails is presented from the URL in question and the user can paste any image URL as well.

WYSIWYG Authoring of Weblines

A system supporting webline authoring, reading, and embedding is available at LineHive.com. The weblines authoring interface requires the user to paste desired URLs into a textbox and press [Enter], whereupon they are added to the webline in WYSIWYG fashion. Hovering over individual items allows the user to refine the date or change the thumbnail. Crucially, as dates on individual items are changed, their position on the timeline is updated immediately, animating to the new position.

We also made timeline creation simpler by automatically downloading a thumbnail from the item's URL (an idea observed in Facebook). Because automatically selecting a representative image is error-prone, the user can refine the choice or enter the URL of a desired thumbnail image (Figure 5b).

Three types of time-scale representations were explored: *relative* (the distance between the items is proportionate to the duration between them), *fixed-interval* (all items are displayed at a fixed distance apart – see Figure 6a), and *fixed-interval clusters* (visual indicators are placed on the timeline to represent significant durations – see Figure 6b). To reduce information complexity, we sacrificed temporal accuracy and used fixed-interval clusters.

The description was eliminated and renamed to 'caption' to prompt a descriptive title. It was also moved below the timeline, resembling a caption to an illustration, to ensure the author is sufficiently descriptive.

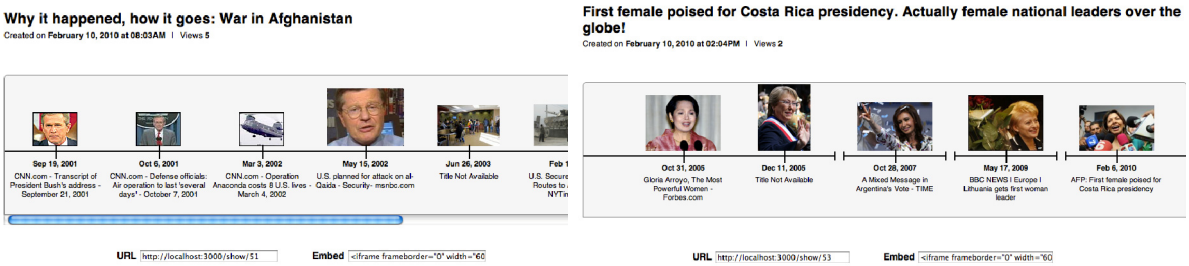


Figure 6a and b. These two weblines illustrate the difference between fixed-interval and fixed-interval with clusters types of time-scale represntations. In (a), the items are placed at fixed intervals regardless of the duration between them. In (b), visual 'time gap' indicators indicate relatively large durations.

Sharing Weblines by Embedding or Hyperlinking

The sequence of webpages that a webline represents is meant to be treated as a unit of information complementing a greater point or standing alone. Each webline has a short URL that can be micro-blogged and can be embedded as a widget to complement articles or blog posts.

Pilot Study: 60 Collocated Participants in a Classroom Setting

We took a high-fidelity prototype of the design to two 9th grade public high school journalism classrooms in an affluent area where students were writing reviews of books by conducting Internet research. They were asked to create timelines to complement their reviews.

The function and form of the caption was effective at eliciting descriptive but not loquacious titles. Though we expected these timelines to be created quickly, the students voiced their opinion to login, save drafts, and revisit the timelines they created. In effect, the timelines became valuable narrative representation of

student thinking and research. They both took longer to create and were more valuable to authors and peers than expected.

Frequently, students would create long timelines with over 10 items that required significant horizontal scrolling, an undesired consequence. They would simply paste links from any URLs they visited during their research, without regard. These quickly became unwieldy and lost their narrative thread.

Constraining Volume and Length to Form Short-form Timelines

Our team inspected a number of print periodicals for examples of timeline narratives. We observed that short-form timelines were used frequently to complement articles or even to stand on their own. These short-form timelines were constrained in both volume (number of items) and length (characters of text). Readers are accustomed to them and they drew upon the same principle that has led to the success of micro-blogging: constraint. We restricted the maximum number of items to 6 and amount of characters to 200 for each subtitle, and the title to 100 characters (to make room for a URL that could then be micro-blogged).

By restricting the volume and length of our timelines would both eliminate horizontal scrolling and, ideally, ensure tighter narratives. By reducing the number of options, authors would have to be selective in their choice of URLs. All items would be visible on one screen at one time, requiring no scrolling whatsoever. This became a guiding principle in the system's design.

Evaluation

Our research question then became, "What characterizes the nature of different weblines and how does the user's exploratory search process inform this nature?"

Participants, Dataset, and Methodology

We deployed LineHive.com publicly and worked closely with three groups of participants to collect data on how it was used and the nature of the resulting timelines over the course of three months. The first group N1, was a classroom of 30 9th grade journalism students. The second group, N2, consisted of 29 journalists for an online magazine who work remotely from one another and conduct weekly teleconferences (and occasional in-person meetings) that our team became part of. The third, N3, was a group of 22 students in a university course on social technologies. The students had weekly reading assignments and, each week, were given the option of writing an essay or creating a webline. In either case, they were shared publicly with the class and on Twitter. In total, there were 81 unique users of the tool. In total, 353 weblines were analyzed (including the research teams' own examples). We collected and analyzed the weblines created by all these participants.

We used a grounded theory (Glaser, 1992) approach to evaluate how users expressed their search insights. We pruned a portion of weblines that were not suitable for analysis. The pruning process was as follows. First, we first omitted duplicates and some improper contents such as racist account (which were likely created by arbitrary web users). Second, we omitted 'test' weblines. Through this pruning process, 252 timelines remained to be analyzed.

We then categorized weblines based on communicative intent. With these initial categories, we re-examined the 252 weblines and refined the categories again. Two category types emerged: "sequence" and "argument." We then pruned items that our team had contributed, resulting in 195 weblines. Weblines in the sequence category pull together links in order to *describe* an event (e.g. "Major events of the Obama campaign") or steps in a process while argument weblines are where the author is using links to make a logical argument or statement (e.g. "How social media changed youth radio").

Results

Among the 195 weblines created, 26 lines deal strictly with chronological report of a current issue (13.3%) (e.g. Figure 7a). In creating these narratives, authors had to choose the most relevant facts to form a sequence of events on an issue. However, chronology of an issue sometimes has longer time span as shown in Figure 7b. Figure 7a was clearly stimulated by the Olympic Games but is focused on its historical aspect. There are 61 historical weblines of this kind (31.3%).

A portion of the weblines go beyond just convey a chronology as Figure 7c illustrates. In this case, the caption delivers creator's argument, and the links are selected as to support the argument, at the same time the evidences became more comprehensive when it is in chronological order. 22 timelines are fallen into this category (11.2%).

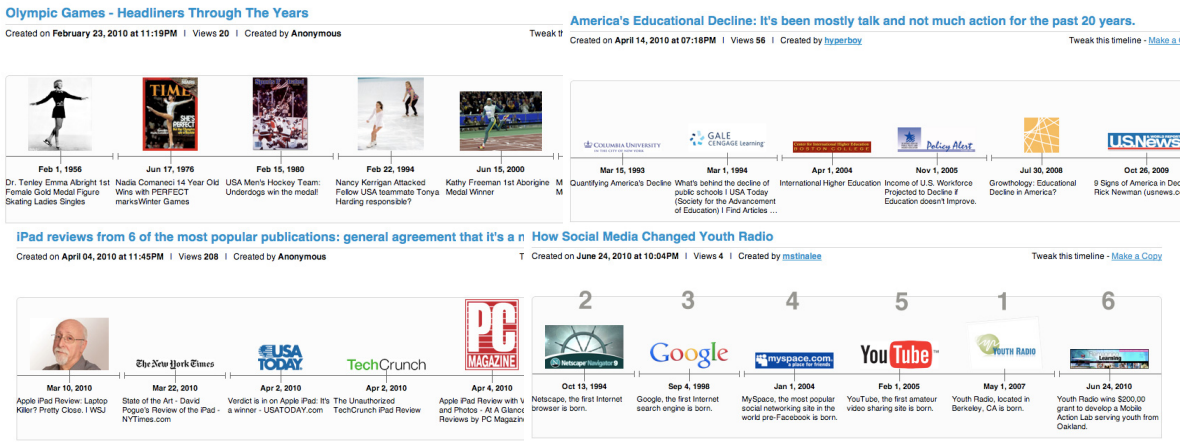


Figure 7a-d, clockwise from top-left. (a) This webline illustrates a chronological timeline that does not present an argument, *per se*. (b) This webline combines a chronology with an argument. (c) The result of a contextual interview we conducted, this webline both makes an argument and presents a chronology of a topic. (d) This webline does not present a chronology of an event but rather a collection of weblines. The numbers on this latter webline indicate the order in which they were added by the author.

In a majority of the weblines that illustrate a well-constructed argument, the chronological order of the URLs is not paramount, as shown in Figure 7d. We labeled this category, which contains 43 weblines (22.0%), "argument by example."

We then created a quadrant graph of the weblines with the two dimensions, plotted in Figure 8 (with counts for each quadrant). One third of timelines made a clear argument but it is not clear whether this type of argument is formed during the search process or beforehand.

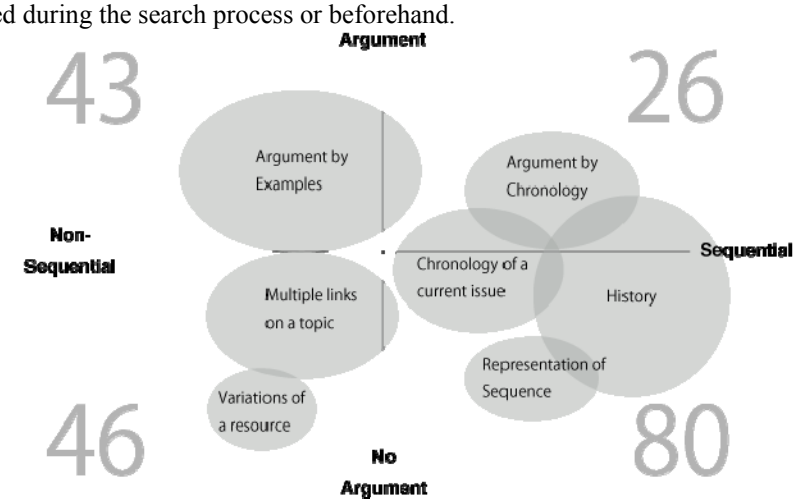


Figure 8. Weblines made using the tool fell into four quadrants along two dimensions: Sequence and Argument. The numbers represent counts. Category descriptors on the circles represent sub-categories.

Contextual Interview with an Expert Webline Creator

We conducted a contextual interview with a participant who created multiple high-quality weblines to see how such insights are developed and transferred into weblines. We tasked her with making a webline related to her expertise in youth's use of social media. We asked her to think-aloud (Lewis, 1982) through this process.

The participant spent 48 minutes talking. We attribute this relatively long duration to the think-aloud and interjecting we initiated. During this time, she changed URLs 58 times, 11 of which were searches. The outcome is as Fig. 7d. The number on each link indicates the order in which that link was added to the webline. This timeline can be plotted in the overlap area between "History" and "Argument by Chronology" in Fig. 8. The webline caption was finalized at the end. Her initial intention evolved significantly over the course of creation. She frequently mentioned the remaining number of link spots available and ran up to this constraint repeatedly. Several times throughout the process, she looked at what she had so far and the forced temporal sequence made her re-evaluate her goal and the most interesting insight to share with the webline.

Arguments shown in weblines may not be directly attributed as an initial insight but the tool galvanizes the exploratory search and insights from the search can be expressed as a selection of the items. In effect, a

number of non-obvious insights can support weblines that are ostensibly made to be arguments or chronologies. Weblines effectively support not only the transfer of insights but also an insightful search process itself.

Discussion and Next Steps

We learned how the exploratory search process can be represented using a metaphor common to print design: the short-form timeline. By translating search skill development into a constructionist (Harel, Papert, 1991) storytelling tool, authors can create weblines individually or collaboratively. Future studies will determine if authors develop exploratory search skills by ensuring their search process develops a narrative arc and, for readers, because exploratory search process is represented by an engaging narrative. It is core to the design that each webline is automatically published in a user's 'stream' so that public sharing is the default.

One reason users iterate on their weblines is because they re-organize themselves based on each link's publication date. This forces users to re-evaluate their choices and address gaps. By having at least one organizing principle (*i.e.* time), the system enforces a level of coherency in the user's findings.

Our representation does not illustrate the author's entire process, as prior work did, but rather the resulting insight. Thus, the trade-off is that authors are motivated to search enough to produce an insight but that this process is more opaque to readers. Future work might reveal this process upon request.

This study has implications for how exploratory search systems are conceived. Currently, search interfaces are designed for solitary use and their results are of use to the user only; sharing is a secondary consideration. It is interesting to investigate search engines as inherently social systems such that the act of using it was to create knowledge for oneself and others. By creating knowledge one knows others will consume, constructionist theory posits that one creates higher-quality artifacts and conducts more insightful searches.

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