An Exploration of Mashups and Their Potential Educational Uses

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ABSTRACT. A Web mashup is an application that combines data and functionality from more than one source. By bringing disparate data together in ways that enable users to do new things or accomplish common tasks with newfound efficiency, mashups are rapidly increasing in number and may offer exciting new possibilities for classroom instruction. However, in comparison to more established Web 2.0 applications such as wikis, blogs, and podcasts, which already enjoy a place in the educational conversation, mashups are less well-known and their educational uses are less explored. The purpose of this article, therefore, is to provide an introduction to mashups as part of Web 2.0 technology, describe several mashup examples, and explore their potential use in educational contexts.

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Recently a friend of ours relocated to a city that was completely new to her. To facilitate the moving process, she used ApartmentRatings.com (http://www.apartmentratings.com/) to find apartments that met her criteria for safety, location, and community makeup. Reading reviews of what current and past tenants had to say about each property also helped her quickly narrow down the rental options. The information significantly shortened the amount of time she spent visiting apartments to identify the property with the best combination of features to meet her needs. Before leaving for the airport on the day of the move, she used Orbitz Traveler Update (http://updates.orbitz.com/) to get real-time information from fellow travelers about security line wait times, parking, taxi lines, and other critical travel information such as local traffic delays and national weather warnings.

In her search for apartments, our friend was actually using a complex combination of Web 2.0 technologies. The ApartmentRatings.com Web site plots rental property listings on a city map while providing resident-submitted information specific to each location. The Orbitz Traveler Update Web site brings together relevant information supplied by the Weather Channel, the Transportation Security Administration, Yahoo! Web Services, and recent passengers. These two Web sites are examples of a relatively new phenomenon in the world of Web 2.0 technology called the *mashup*. According to Wikipedia (Wikipedia, Mashup, 2007a), a Web mashup is an application that combines data and/or functionality from more than one source. In other words, mashups bring disparate data together in ways that enable users to do new things or accomplish common tasks with newfound efficiency.

Mashups are rapidly increasing in number and support a variety of tasks and interests. The Programmable Web, a mashup clearinghouse Web site (http://www.programmableweb.com/mashups), hosts over two thousand mashup applications and states that an average of three new mashups are added daily. Although upward trends in both mashup creation and use are encouraging, their potential for classroom use has yet to be systematically examined. In comparison to the more established Web 2.0 applications such as wikis, blogs, and podcasts, which already enjoy a place in the educational conversation, mashups are less well-known, and their educational uses are far less explored and documented. Mashups may, however, offer

exciting new possibilities for classroom instruction, leading to potentially innovative uses of existing Web applications and data. The purpose of this article is, therefore, to discuss mashups and their relationship to Web 2.0, describe mashup examples, and explore their potential for educational use.

MASHUPS AND THEIR RELATIONSHIP TO WEB 2.0

Mashups and Web 2.0

The Web was originally developed to be a relatively straightforward system to support the communication of information between individuals and groups (Berners-Lee, 1998). Hypertext Markup Language (HTML), the primary computer language used by Web developers to design Web pages, was created so that people could design, distribute, and consume information in a standardized manner. Consequently, during the years preceding Web 2.0, much of the early work surrounding the Web was related to the ways in which text-based information, and later multimedia, could be more effectively delivered to the consumer. While the Web grew to become an incredibly vast collection of information, it lacked practical ways for its different data stores to be shared and repurposed. In short, the Web was developed to be read by human users in specific ways with computers serving in a role largely limited to data storage, retrieval, and transmission.

As a result of its rapid and somewhat haphazard expansion, HTML became recognized as increasingly convoluted, with a growing potential to introduce problems into the Web-browsing experience (Pemberton et al., 2000). In response, the World Wide Web Consortium (W3C), the group tasked with developing guidelines for Web authoring, proposed a number of ideas to streamline the process of creating and presenting information on the Web. This effort resulted in a number of new languages and technologies, including the Extensible Markup Language (XML), Extensible Hypertext Markup Language (XHTML), and Cascading Style Sheets (CSS). These technologies became enabling elements in the Web 2.0 revolution and led to the creation of additional technologies, such as Really Simple Syndication (RSS), the Resource Description Framework (RDF), and Asynchronous JavaScript and XML (AJAX). Web 2.0 applications in general and mashups in particular exist today because these new technologies provided the tools necessary for flexible and dynamic data sharing, organization, display, and reuse.

These innovations were critical to the development of Web 2.0 technologies partially because they enabled the creation of the *Semantic Web*. The Semantic Web is a notable departure from the traditional Web because it allows different information sources to be linked together, affords sharing content between multiple Web applications, and provides ways to combine online services (Hendler, Berners-Lee, & Miller, 2002). The core idea behind the Semantic Web is that machines can be used to process and manipulate information in fairly sophisticated ways (Tauberer, 2006). By using standardized methods for storing data, computers can synthesize seemingly unrelated information, process that information, and generate new applications for Web users. This essentially describes the nature of a Web-based mashup.

While the underlying technology of mashups denotes a clear association with Web 2.0, there are also a number of social features embedded within the idea of the mashup that tie its creation and use to the human culture surrounding Web 2.0. Web 2.0 is developed as a user-centric environment that is social, personalized, interactive, and participatory. It elevates the role of the user to a more central position by placing value on and trust in the messages that users produce. With the emergence of blogs, wikis, photo, and video sharing sites, Web users themselves have become content creators, asserting personal and collective control over the type, tenor, and tone of information they choose to create, transmit, and consume.

O'Reilly (2005) discusses user-contributed information in Web 2.0 as a form of collective intelligence. Mashups acknowledge the role of the user by providing ways for user data to be combined, repurposed, reorganized, and in some cases added or edited. Blogs, wikis, and media repositories (such as Flickr and YouTube) are excellent sources of user data for use in mashup applications. User-generated tagging strategies, known as folksonomies, are found in Web 2.0 applications (such as the del.icio.us social bookmarking site) and improve the ways in which mashup developers access, sort, and filter information by providing human-readable and often more flexible ways of describing data.

Mashups rely on external data for some, if not all, of their content and many of the best content sources come from popular Web 2.0 applications. Mashups extend Web 2.0 applications by repurposing their vast user-created, freely available stores of information and services. In doing so, mashups increase the visibility of Web 2.0 applications and their content.

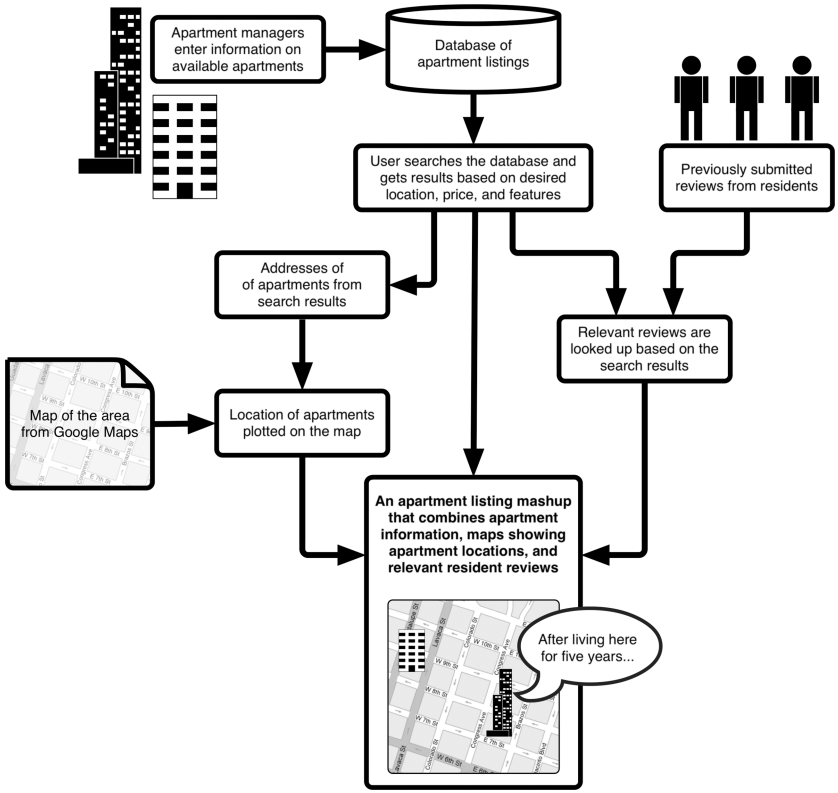
Defining the Mashup and Its Characteristics

Combining information from two or more sources on the Web (Hof, 2005; Wikipedia, Mashup, 2007a), mashups can include text, graphics, maps, video, or various other forms of digital media. A specific mashup combination is made possible when Web sites make their data available to external programmers through application programming interfaces, or APIs. APIs include pieces of computer code that give outside Web applications permission to query and retrieve data and display it on their Web site. Orbitz Traveler Update, for example, uses the Yahoo! Web Services API to retrieve traffic data from Yahoo!. These data are then placed inside a map retrieved from Google using the Google Maps API. While the map and traffic data are available on other Web sites, the existence of APIs makes it possible to display and even combine these data in ways that are especially useful to the Orbitz Traveler Update target audience.

Because the data retrieved via APIs are systematically structured and readable by computers, it is possible for computer programs to interpret, manipulate, and combine the existing data to support the creation of novel and potentially helpful Web applications. With this approach, Web service providers may no longer be required to go through the expensive and time-consuming tasks of creating, storing, and updating all content required in providing their service. Using the earlier apartment search example, Figure 1 visually illustrates the inner workings of a mashup application.

In discussing the definition of Web 2.0, O'Reilly (2005) proposes a set of principles that he considers to be important in differentiating Web 2.0 from earlier models of Web content creation, transmission, and consumption. Many of those principles reflect the characteristics of mashups. The most closely related principles include hackability, remixing, the long tail, and the idea of creating a large system by joining small components. Hackability, in a mashup sense, describes how Web programmers can bring components from existing applications into applications of their own and manipulate them to serve a new purpose. This notion of hackability is obvious when considering the use of Web application APIs, which make reusable components available in the form of programming building blocks that can be manipulated, or hacked, by programmers. O'Reilly's idea of remix comes into play when discussing mashups because it points to the trend in Web 2.0 of gathering resources, mixing them together, and creating a new hybridized resource. O'Reilly's long tail principle denotes an orientation toward comparatively small niche groups of users. For example, while the majority of Web users have e-mail accounts, only a fraction of them

FIGURE 1. Visual illustration of how ApartmentRatings.com mashup works.



need resident-created comments on apartments located in a particular city situated within a map. Lastly, nearly every mashup is created by combining small components to create a new application (the mashup)—making use of Web 2.0's common emphasis on small components that can be joined together.

Initially, remixing or joining Web 2.0 data sources was a technical process that required developers to gain a robust understanding of the specific functionality of Web service APIs before using them to write the code that would actually combine data and functionality. Recently, however, a number of graphical mashup editing tools have emerged that significantly simplify the process of interacting

with APIs and creating mashups. These tools, such as the Google Mashup Editor (http://editor.googlemashups.com/), Yahoo! Pipes (http://pipes.yahoo.com), and Microsoft Popfly! (http://www.popfly.ms), are equipped with visual interfaces that allow users to drag and drop data points into a Web application. Mashup developers provide the data source URL and select the API modules they want to include from a list of available features. These editors not only simplify the process of remixing data sources, but they also offer nonprogrammers the chance to create their own mashups without confronting the steep learning curve associated with JavaScript, Python, PHP, Ruby, XML, or other computer languages.

EXAMPLES OF CURRENT MASHUPS

While a comprehensive survey of existing mashups is beyond the scope of this article, outlining several of the most common mashup types along with an example of each should give the reader a good grasp of the current mashup landscape. Here we describe a few typical examples grouped around three of the most popular data sources used in mashup creation: maps, images, and news.

Maps

As commercial, governmental, and nonprofit groups developed Web presences to promote their services, the inclusion of maps to orient Web viewers to a group's physical location became the norm. Mapquest, Yahoo! Maps, and, later, Google Maps offered dynamically generated maps and the ability to produce driving directions between a user-entered location and an online entity's physical address. More recently, the release of the Google Maps' and Yahoo! Maps' APIs has led to a proliferation of geography-based (geo) mashups. The mapping APIs have afforded mashup developers the opportunity to situate content within a two-dimensional geographic environment. From images to video and from blog posts to storm fronts, mashups that locate different types of data within a mapping interface organize content in ways that can possibly reduce extraneous cognitive load (Sweller, 2006) and support different ways of knowing. HoboMap is such an example.

HoboMap (http://www.cyberhobo.net/hobomap) positions blog posts within a geographic space via the Google Maps API. Posts are color-coded by topic and marked within a map of the western United States. A

mouse-hover yields the blog entry's title while a click opens a within-map bubble containing the title, the first 30 to 40 words of the post, and a link to the actual blog entry. Originally created for an individual Web site, the technology behind HoboMap has been converted into a plug-in for use with the popular blog software, WordPress, allowing the larger blogging community to geographically situate their posts. This type of mashup affords bloggers an alternative, atemporal, nonlinear way of blog post organization and display. Blog readers specifically interested in notions of place are given a way to navigate and interact with topics and posts pertaining to specific geographic locales.

Images

Better multimedia file compression and growing bandwidth emerged in the late 1990s to transform the Web from a largely text-based format to an image-rich environment. The proliferation of increasingly capable and affordable digital cameras as well as camera-enabled cell phones facilitated photo sharing as well as photoblogging (blogging via images). Image-centric Web 2.0 applications such as Flickr and Photobucket, whose APIs have subsequently spawned numerous mashups often involving image search, retrieval, and juxtaposition, contain hundreds of millions of images. The following example demonstrates how mashups can add value to the process of searching for images.

Why use words to search for images? Retrievr (http://labs.systemone.at/retrievr/), created by System One Labs in Austria, serves up publicly viewable Flickr images based on user-created drawings within an interactive sketch area or via comparison with user-uploaded images. While currently in an experimental phase, the technology, inspired by the image retrieval work of Jacobs, Finkelstein, and Salesin (1995), supports play and wondering about notions of similarity that do not rely on language or word-based groupings and instead focus on color, spatial juxtaposition, and chance. Helping people think differently, Retrievr shows how mashups can reinvent search in a Web 2.0 way where unique user-created or uploaded images are used to search for similar images. It provides a test bed for image-to-image search algorithms while simultaneously offering a new way for users to query a database of over 230 million photos, drawings, and graphics (Arrington, 2006).

News

The proliferation of news sites, news articles, and news-following blogs makes for a dense tangle of text-based, audio, and video news pieces on subjects ranging from the War in Iraq to education in Rwanda—produced and published by entities representing internal, external, left, right, corporate, and independent perspectives. Created in the spirit of the mashup, Google News, with its aggregated news feeds from over 1,700 sources (Wikipedia, Google News, 2007b) set the bar and laid the groundwork for more recent mashup developments. The news mashup example that follows allows for entity-based navigation and sense making.

While most news sites and aggregators organize their content by events, the Optevi News Tracker (http://www.optevi.net/newstracker/) leverages the ClearForest API to serve up news based on entity type in a text-centric visual display of current news stories grouped by individual, location, or thing while conveying the number of articles per entity via text size and color. A mouse-hover turns the text green and triggers a popup preview of the entity's content. Once a selection has been made, links to news stories and blog commentary appear.

MASHUPS IN EDUCATION

Given the previous discussion of the composition and use of mashups, what might constitute their educational potential, and how can we as educators leverage their affordances in our teaching endeavors and creation of learning environments? Although not all mashups have obvious educational value, the creativity of teachers and students, the high levels of user-generated content, and the ability to visually render data make some mashups especially suitable for use in educational contexts. Learner needs, local realities, teacher dispositions, and curricular foci can and do converge in ways that allow for the integration of mashups suitable for particular classroom learning situations. That said, the nascent nature of the mashup landscape in educational settings and the absence of empirical data dissuade us from offering prescriptive commentary as to how mashups might be used to support learning. Rather, in thinking about the potential for mashups, we describe a few carefully selected candidates for classroom use and put forth several teaching ideas for educators to consider. More specific uses of mashups should come about through

the local efforts of educators and through research-based initiatives that systematically examine mashup use in educational practice.

Molecular Visualization Wiki

Asynchronous collaborative visualization systems merge existing interactive visualization programs with text-driven wikis. The Molecular Visualization Wiki is one such mashup example. Combining Jmol, an open-source molecule viewer for chemistry, and the chemistry-related content found in the JSPwiki Wiki engine, the mashup supports dynamic annotation, information foraging, and session playback for visualizations. Users can input script commands that work with different visualized combinations of molecule structures, enter comments, and edit documents to share hypotheses and observations. From a design perspective, Marchese and Brajkovska (2007) suggest that the ability to embed a graphical application into a wiki creates a powerful system for asynchronous collaborative work and theorizing. By mashing up these tools in a way that maintains much of their original functionality, the need for specialized software designed to support collaborative visualization is met with little additional development time and effort. Such a tool, designed for practitioners in the field, simultaneously affords novices not only an opportunity to learn but also a chance to peer into specialized domains and the communities built around them.

Mapskip

Leaving handprints across the world might be an apropos tagline for this narrative-based Google Maps-supported mashup. Created in August 2007, Mapskip (http://www.mapskip.com/) invites users to mark points on the map and add their stories, images, and audio to the different places they have lived, visited, and experienced. Other users can comment on the posts, add their own stories about the place, or join in conversations about the place itself. The use of Google Maps allows stories to be placed on a global, regional, local, or neighborhood level—supporting different types of integrated social studies, geography, and creative nonfiction writing units/lessons. This mashup can be useful in that, instead of simply repurposing different types of externally created data, Mapskip's stories, narrative, and audio are solely the products of its users—affording activity possibilities that draw on the user's background and help value Funds of Knowledge (Gonzalez, Moll, & Amanti, 2005).

TerraClues

Another Google Maps-based mashup, TerraClues (http://www.terraclues.com/), is designed as a multi-grain-size where's Waldo, only instead of finding a skinny man in a striped shirt, users are challenged to locate historic or locally relevant landmarks based on clues, their domain-specific knowledge, and Internet search acumen. Dozens of quests called TerraHunts currently exist and users can create their own, allowing students to benefit from both hunt creation and play. As with Mapskip, this mashup leverages the effort and interests of its own community for content creation, not only making district, campus, and teacher-created quests possible, but also allowing learners to create their own quests based on individual interest or as part of in-school history, biology, literature, or geography projects.

KQED Quest

Leveraging Google Maps to place their content geographically and Flickr to store their image media, KQED—a Northern California public broadcasting radio and television station—has created a quest that focuses on the environmental and scientific issues affecting the San Francisco Bay area (http://www.kqed.org/quest/). Video, audio, graphic, and print-based materials are geo-tagged and used to create educational, theme-based explorations. The site also offers educator guides, teacher workshops, and advance organizers for students. Its content is not only mapped onto a satellite image of the bay area but pathways through the content are also suggested. An integrated blog affords users the opportunity to ask questions and give feedback.

Ficlets

Language arts teachers searching for motivational writing devices may want to consider Ficlets (http://ficlets.com/). This mashup encourages users to collaborate on short fiction writing. By getting inspiration from random Flickr images, story starters, story endings, or quotes, students can either write an original short story, or write a prequel/sequel to a story that has already been written by another user. Teachers can comment on students' writing and students can comment on one another's stories. The randomness of the Flickr image prompts and the collaborative nature of the writing process within Ficlets combine to encourage and support a

wide array of creative writing styles and topics. Additionally, since the stories are published on the Web, students may be more motivated to write for an audience that could include parents, peers, and fellow writers.

Other mashups that can be used in different subject matter areas include, for language arts/literacy, Similar Products Visualization (http://imagine-it.org/amazong/vissimweb.htm), which helps users get information on similar books via data sources from Amazon.com, making it easy to locate a reader's next book or books; for science, Astrolicio.us (http://astrolicio.us/), which uses data from Hubble Space Telescope Image Database, Digg, Google, YouTube, and del.icio.us to provide current, detailed astronomy-related information in modally diverse and accessible ways; and for social studies, Saga Earth (http://www.saga-earth.com/), which helps locate countries and relevant videos that provide visual supplementary materials for the geography classroom.

CHALLENGES OF USING MASHUPS IN EDUCATION

While mashup use in classrooms offers exciting ways to rethink educational application design via the leveraging of existing, freely available content, we feel compelled to point out some mashup-specific challenges that lie ahead. As compared with other Web 2.0 applications, mashup technology is still very much at its beginning stage, rendering its educational potential less known and its strengths ill defined. Below are some issues educators may confront in using mashups in the classroom.

Data accuracy, content appropriateness, and stability may play significant roles in how mashups are used in education. Since most mashups utilize editable, dynamic, user-generated data, issues of content unpredictability emerge. Herein we will use some of the mashups already discussed as examples.

Although the Ficlets mashup supports the creative writing process in ways language arts educators may value, its use of the Flickr API that creates the small but very real possibility that students may be exposed to materials deemed inappropriate for some K–12 classrooms. Along the same line, while the narrative and image content of the Mapskip mashup may look like a good fit during a pre-class preview, the content may change in unanticipated ways between the preview and its in-class use.

A lack of mashup development expertise and/or resources within educational circles may constrain widespread mashup use and adoption. The creation of a mashup requires a ready supply of raw data, technical know-how,

a spark of creativity (Fitcher, 2007), and an understanding of the design's target domain as well as the needs of the intended users. A community of educationally focused mashup developers has yet to be identified. Most publicly available data used in mashups today (e.g., Flickr or YouTube) are not designed for educational purposes. Content developed with instruction in mind may speed up the creation of educational mashups, leading to more widespread use of mashups in education.

Immaturity in the level of technical support offered to novices interested in mashup creation may also be a limiting factor. Although mashup editors such as Yahoo! Pipes and Microsoft Popfly! simplify the process of creating mashups, most are still in the developmental stage and the built-in API modules remain limited. Moreover, in some visualized editors, there is often no way to view the code that makes the API calls, thus making it hard to replicate, modify, or conduct advanced editing of a mashup product.

Peripherally, copyright issues may give educators pause before investing the time to develop mashup solutions to curricular challenges (Boulos & Wheeler, 2007). Lamb (2007) suggests three questions every educator should consider while designing a mashup: What constitutes a valid original work, what are the implications for how creativity is assessed and rewarded, and what are the risks of permitting this type of activity?

Given the current nascent and constantly evolving nature of mashup technology and its limited use in educational settings, research centered on mashups as educational tools has yet to surface in educational journals.

LOOKING AHEAD

In his book *The Tipping Point*, Gladwell (2002) chronicles social epidemics, noting how certain subtle factors work together to create environments that allow for previously unknown or unpopular items or ideas to become popular and ubiquitous seemingly overnight. It is easy to see how this relates to many Web 2.0 applications. Despite the absence of world or nationwide marketing campaigns, Wikipedia, Flickr, Blogger, and YouTube have all gained a place in the pop culture consciousness and begun to make inroads into schools and classrooms. Given the lesser known and little explored phenomenon of mashup use in education, it is necessary to raise its profile with educators—pointing out both its challenges and potential.

While significant constraints exist, there is reason to believe that a tipping point might be reached in the next few years. As increasing emphasis is placed upon developing skills and habits of mind necessary for participation in knowledge economies that require a capacity to manage complex, dynamic, sometimes random data in specific ways, the role of mashups becomes more prominent. Mashups offer new, alternative, and hybridized ways of viewing and manipulating internally or externally created content. Instead of simplifying, mashups often help manage complex data by embedding it within rich representational environments that have the potential to support holistic understandings of a topic or concept. With such authentic data manipulation, educators can situate classroom learning in real-world contexts, creating difficult, true-to-life problems for students to solve as they hone their higher order thinking skills while becoming facile in navigating high levels of data complexity, volume, and change.

The dynamic, high volume nature of the information many mashups contain provides learners with opportunities to develop several of the key elements listed in the 21st Century Skills framework (Partnership for 21st Century Skills, 2006). This is accomplished through a focus on core subjects like geography, science, and history, on 21st century content via global awareness and civic literacy, and on information and media literacy skills via data/information filtering and decision making. Mashups using maps, news, and rich media (e.g., images, video, and audio) are particularly suitable for this purpose.

Additionally, mashups that leverage internally created (often low volume) content provide an environment supportive of distributed learning (Dede, 2004) and community building through reflective, asynchronous interaction and creative expression. Teachers and students can create contextualized mashups to support their own learning needs. These too are skills and abilities required in the new millennium where individuals work on team projects and negotiate the integration of diverse ideas and experiences.

Finally, the potential for mashups to repurpose freely available content in educationally valuable and cognitively accessible ways may push mashups toward their potential for social epidemic status.

In summary, mashups, with their dynamic, interactive, participatory nature and focus on authentic and publicly accessible data, should support classrooms in which students are encouraged to take an active role in their learning and may provide new and different opportunities for teachers to teach. This relatively new Web 2.0 paradigm is evolving and its educational uses have yet to be examined, understood, and exploited. Research on

the design, development, and implementation of educational mashups is required if the full educational potential this approach embodies is to be realized.

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