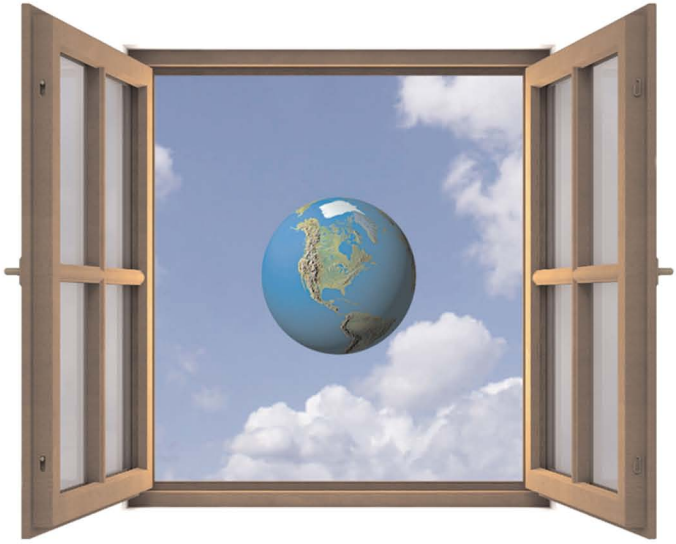
OPENING UP EDUCATION

The Collective Advancement of Education through Open Technology, Open Content, and Open Knowledge



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To our wives and sons—
Hiromi, Rukmini, Ken, Suhas, and Taku
—whose support and encouragement makes this important work possible.

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Designing Open Educational Technology

David Kahle

A common observation made by those skeptical of the open educational technology movement is, "you get what you pay for." The implication is that products developed without the benefit of sustained commercial investment, and lacking the control structures and accountability identified with centralized, for-profit incentives, will be certain to disappoint.

While investment and organizational practice certainly have an impact on product outcomes, assessing a technology's value in terms of finance and governance models alone fails to recognize another, perhaps more accurate, predictor of open technology success—design. Rather than "you get what you pay for," the sentiment "you get what you design for" may be a better characterization of open educational technology's potential to positively affect teaching and learning. Simply put, design matters. Designers have a greater influence on outcomes to a much greater extent than is often recognized.

Design is a highly influential, value-laden and reflective practice which, within our context, must mirror, accommodate, and reconcile the values and assumptions intrinsic to open education. A number of values, or principles, often associated with open education may serve as a foundation for open technology design theory and practice. These principles include access, agency, ownership, participation and experience. Highlighting the core values of open technology and defining these as principles of design practice is an important first step toward accelerating the production and ultimately the adoption of innovative educational software that honors the complex needs and interests of educators and learners alike.

The Primacy of Design

In understanding the role of the designer in open educational technology development, it is helpful to begin with an inclusive rather than restrictive notion of design and to recognize how directly theories and ideas regarding design influence practice. Starting with an expansive, holistic approach to this topic—the idea of design at large and the general relationship among design values, theory and practice—encourages us to appreciate design as both a product and process that has a residual effect on educational environments, resources, and the activities they support.

Design as Practice and Problem Solving

Design can be seen as pragmatic, rooted in problem solving, reflective, and consequential. Often the impetus and motivation for design springs from problems, conundrums, and challenges. These may be as grand a challenge as providing universal access to education or more personally focused, such as integrating an open educational technology into one's own curriculum. When we are deliberate in our approach to articulating a solution to a problem which faces us, we actively engage in the process of design and we become, in a very real sense, designers.

And the design of effective educational technologies is something we can pursue, control, and take responsibility for. It is our approach to design, however, our methods of identifying and addressing the issues surrounding open educational technology that determines a design's effectiveness, relevance, and elegance.

Design Theory and Values

Approaching technology design as a common activity rooted in problem solving is to see the design process and its outcome as a means to an end. It is these "ends" that consciously, and at times unconsciously, inform our approach to problem solving and our practice of design. Goals and values shape the design theories that, in turn, guide our approach to technology development. Therefore, understanding design within the context of open educational technology development necessarily requires an awareness of the roles and origins of those design theories that inform our practice. Where such a theory is lacking, as I believe is the case with open technology development, there is a need to make

explicit a set of principles, goals or values that can serve as the basis for a useful design theory.

The role of design theory is to introduce frameworks for prioritizing and analyzing design problems. The twentieth-century Swiss architect Le Corbusier, speaking in reference to his Modulor system of proportions, captures the general purpose of design: "Architects everywhere have recognized in it, not a mystique, but a tool which may be put in the hands of creators of form, with the simple, aim . . . of 'making the bad difficult and the good easy'" (Le Corbusier, 1966, p. 5). Creators of open educational software are also in need of a tool, a theory of design, to guide their practice in this important area. It must, however, be based upon suitable principles.

Design Theory and Open Education

Open education brings with it its own set of goals, values, and aspirations that transcend any specific project or functional quality of technology. Open education, open content, and open source as a collective idea is often discussed as a means to liberation (Unsworth, 2004), empowerment, and democratization (Vest, 2006). Equal access to current knowledge and a standing invitation to everyone to participate in advancing new ideas are common themes of the open education movement. How can any design theory informed by such a grand set of values be, at the same time, of any practical use to developers of open education technology?

Adaptable Design Principles

Perhaps the answer to this question lies within the idea of open education itself. Rather than attempting to derive a narrowly prescriptive theory of design for all open educational technology projects, articulating a small set of adaptable design principles may prove more practical. A design theory that could flexibly co-exist alongside multiple approaches to educational technology design, one that does not attempt to subsume or oversimplify the complex practice of educational software development would stand a better chance of adoption and, in turn, be more influential.

Those creating educational software often draw upon multiple descriptive and prescriptive theories, depending upon their specific set of

instructional or learning objectives (Reigeluth, 1999). These may include cognitive theories that describe how humans process information, instructional design theories that offer guidance on the necessary components of a learning activity, or visual design theory that guides interface development. A design theory for open educational technology is intended to supplement these important design considerations.

This new design theory would raise an additional set of questions (problems) based on the values of open education that are best addressed (resolved) during the design process. Again, rather than advocate for a "one best theory" for educational technology, the goal is to broaden existing design and development practices through translating some key values of open education into pragmatic design principles. Toward this end, I propose five principles of design that I believe to be critical to the success of open educational technology. While not exclusive to open technology design, these qualities reflect some of open education's highest values:

1. Design for access.
2. Design for agency.
3. Design for ownership.
4. Design for participation.
5. Design for experience.

Although principles alone do not produce useful and open educational technologies, the ideas associated with this basic set of design principles can serve as a guide to technology creators.

Open Technology Design Principles and VUE

The Visual Understanding Environment (VUE) project currently underway at Tufts University serves as a case study to illustrate the benefits and challenges of adopting these design principles for open educational technology.

VUE is an open source application designed to facilitate thinking, teaching, and learning with digital resources. An important goal and challenge of the project is to develop an uncomplicated, highly flexible and adaptable toolset for structuring information in support of the widest range of scholarly interests and activities.

VUE provides users with a flexible, visual interface for locating, annotating and establishing relationships among local and networked information, including Web resources. VUE has been described as concept mapping meets digital libraries and figure 2.1 supports this characterization.

While the functionality of VUE 1.5 reflects the open technology design framework presented earlier, some of the features described below are currently being implemented as part of the VUE 2.0 scheduled for release in fall 2007.

Guiding the VUE project is a strong desire to create tools that make working and thinking with digital resources intuitive, instructive, and enjoyable. A common educational challenge facing teachers and students is that well established approaches to organizing and managing print material in support of scholarly activities are either cumbersome or impossible to implement when working with digital content (Sellen and Harper, 2002). We regularly rely on margin annotations, Post-it notes,

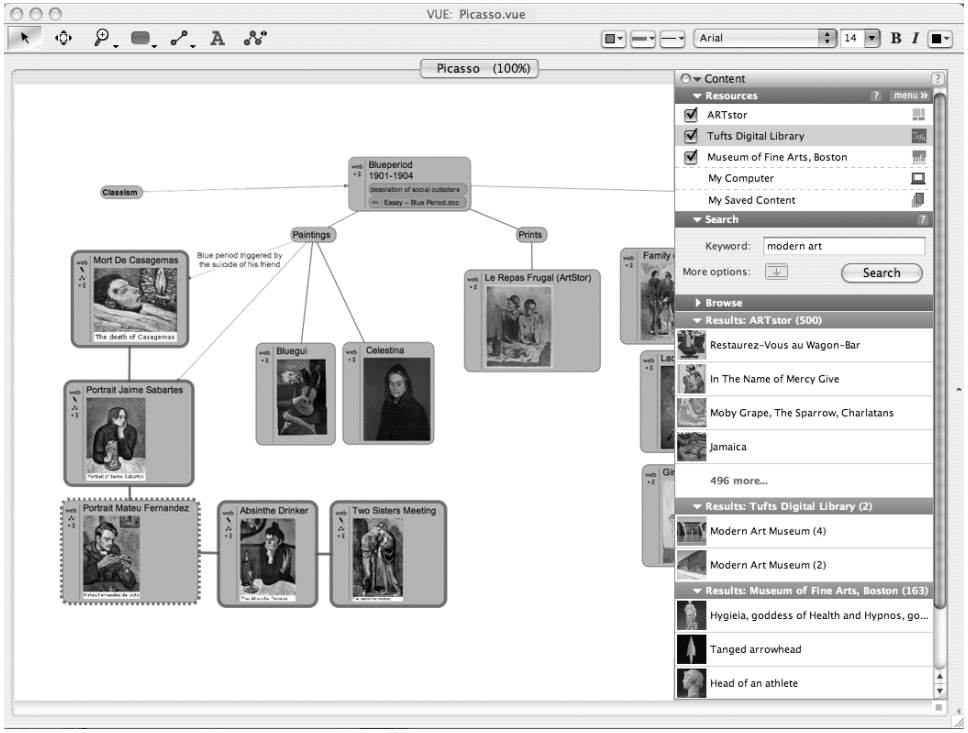

Figure 2.1

and even carefully arranged stacks of papers as a means of processing and integrating new material and ideas into our work. While today we have many powerful applications for locating vast amounts of digital information, we lack effective tools for selecting, structuring, personalizing, and making sense of the digital resources available to us.

In addition, many of our most popular learning management systems accommodate only highly generalized educational contexts where the primary design goal is the efficient distribution of content rather than student engagement with and exploration of new material. Such technologies limit how content is organized around complex concepts, how information is presented, and the degree to which students may interact with instructional material. Restricting access to information, limiting engagement and participation, and providing learners and instructors with little control over the learning activity, materials, or processes creates a demotivating experience. It is this condition that the open technology design framework attempts to address.

Designing for Access, Agency, Ownership, Participation, and Experience

This basic theory of design provides a beginning framework against which the myriad design questions that occur as part of design and development processes may be evaluated and addressed in an open manner. The intent of this framework is not to be prescriptive or to provide specific guidelines for software development, but to increase awareness of a few key ideas that greatly influence the openness, flexibility, and value of technology for education. Though each design quality is treated separately below to elaborate its specific merits, in practice these principles are highly interrelated and overlapping. They are influenced by existing approaches to technology design and, to a large degree, may be viewed simply as different perspectives on a common set of open technology design values.

Design for Access

While each of the design principles presented within this framework deals in one way or another with access, highlighting access as a primary design consideration for open education speaks directly to the question

of "open for whom?" Approaching access from the perspective of open education compels us to think more holistically about potential barriers to obtaining, operating, and thinking effectively with technology and information than is often the case with strictly open-source technology initiatives.

Traditionally, the idea of access as it relates to open technology has been cast in terms of ubiquity and affordability. Software or content that is priced beyond the reach of educators and learners or which requires a sophisticated technical infrastructure available only to a few can hardly be considered open. However, simply because a resource is free or readily available does not mean it is accessible and useful to individuals.

Design for access in this context not only enables the acquisition of open resources but effective thinking, learning, and doing with them. Beyond simply addressing technical and economic obstacles to technology adoption, design for access challenges us to recognize, accommodate, and design with individual cognitive and physical differences in mind. Existing design theories such as *universal design* and its latter extension to education, *universal design for learning*, address these dimensions of accessibility and offer useful guidance to designers and developers of open educational technology. A goal of universal design (UD) as articulated by Mace (2006) is to design "products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." Qualities such as "flexible in use," "equitable use," "simple and intuitive," and "tolerance for error" are emphasized in universal design. In a similar spirit, universal design for learning (UDL) stresses access to learning over simple access to information by accommodating student differences in cognition.

Many educational software applications such as VUE are designed for general educational purposes and may not approach accessibility from a specific curricular objective. However, even open content and technology destined for integration into varied learning contexts can be designed for access. Standards such as those advanced by the W3C's Accessibility Guidelines Initiative and Section 508 of the U.S. Rehabilitation Act outline reasonable measures that can be taken to accommodate individual cognitive and physical differences. Applying such standards and leveraging the inherent flexibility of digital media to provide users with alternative ways of engaging with resources and of enabling integration

with other assistive technologies defines open access in terms more meaningful to a diverse learner audience.

Through Flexibility, Access to Knowledge In support of open access as defined above, VUE is designed to assist individuals in making information meaningful by supporting processes beyond simply locating or acquiring data. Perhaps most importantly and in direct support of individual differences, VUE does not assume how information will be organized, but rather offers teachers and learners the flexibility to structure content in any manner that suits their needs. This flexibility provides access to knowledge in at least two ways.

First, VUE supplies learners with a rich environment within which to establish, explore and reason about important relationships among ideas and information in their own terms and, second, at the same time, it captures this process in a form visually accessible to others. The design goal of making information visible and accessible to diverse learners participating in a range of educational contexts required a design approach that abstracted and simplified the manner in which digital content—whether local files, Web-based resources, text, or multimedia—was represented and manipulated. Guided by this priority, concept-mapping conventions consisting of simple links and nodes were identified as a suitable foundation for VUE's graphical user interface to digital resources. By adopting a simple but flexible visual language for expressing complex relationships among ideas and information, VUE's value as a tool for thinking with and about digital content accommodates a variety of user communities.

One challenge to designing for access lies in reconciling the practical importance of appealing to general interests and cognitive similarities across populations with the desire to address individual differences. The design of VUE's feature set is meant, in part, to address this challenge and, to date, progress toward this goal is encouraging. VUE provides alternate methods of viewing and working with digital resources and tools for scaffolding the development and presentation of content maps.

For example, VUE directly supports visual thinkers through its rich graphical controls for expressing complex relationships among digital resources and, at the same time, supports the manipulation of this map

content via editable hierarchical lists for those more comfortable working with text. Likewise, while many learners appreciate the freedom of a blank map canvas, others benefit from more structure. Educators may scaffold mapping activities using imported ontologies to guide the types of concepts and relationships used in exploring a topic. Maps constructed with such controlled vocabularies may then be analyzed computationally as another means of assessing similarities and differences among student understandings.

VUE's tools for interactive presentations also reflect a commitment to access to knowledge by addressing the difficulties people often experience when trying to integrate complex information. Noting the inherent limitations of common, linear presentation tools, Edward Tufte writes, "The slide serves up a small chunk of promptly vanishing information in a restless one-way sequence" (2003). Designing for access led the VUE team to development mechanisms by which people could focus in on a specific piece of information as part of the presentation while maintaining a sense of its place in context.

Design for Agency

While design for access focuses our attention on expanding access to technology across multiple dimensions, designing for agency highlights design's influential role in determining the degree of user action and control over these open educational resources. This focus on agency compels developers of open technologies to consider the broader social and political context within which a technology will likely be used and how design decisions ultimately impact that environment. Designing for agency anticipates technology's conditions for adoption, its flexibility, and its potential for adapting to local needs and requirements. Here, openness of technology is measured by the degree to which it empowers users to take action, making technology their own, rather than imposing its own foreign and inflexible requirements and constraints.

Those with even limited experience in deploying new technologies within an academic community are highly aware that the conditions for success extend well beyond the technical. The phenomenon of unintended consequences surrounding technology integration is partially a symptom of naïve design processes that view technology as neutral and

fail to recognize the downstream sociopolitical consequences of technical design decisions.

As one example of the larger impact of technical design and choice, Langdon Winner cites the development of the mechanical tomato harvester in the 1940s. "To accommodate the rough motion of these harvesters in the field, agricultural researchers have bred new varieties of tomatoes that are hardier, sturdier, and less tasty than those previously grown." Winner continues by noting that the size and cost of the harvester favored highly centralized forms of agriculture and reshaped control, authority, and social relationships within California's agrarian communities (1986, p. 26).

Colleges and universities have implemented their own "tomato harvesters" with the best of intentions. The design and subsequent implementation of many campus-wide course management systems (CMS) impose their own hidden but consequential requirements that directly impact the nature of online education. These include the need for centralized administration and control over what and when new tools will be introduced, inflexible notions of the relationship among students and teachers, and a limited view of what a course is and how information should be organized. Failing to consider agency as a design criteria for open educational technology increases the likelihood that new educational tools may bring with them requirements at odds with the values and ideals of open education. They may unintentionally limit rather than expand options for a technology's deployment and use.

Designing flexible and adaptive technologies that minimize technical and organizational overhead and which place students and educators at the center of control harnesses technology's transformative potential for education. The value of simple and versatile tools is not lost on learning communities. Today, students and educators are eagerly adopting, adapting, and combining smaller online tools such as blogs, wikis, and instant messaging applications in support of teaching and learning scenarios not possible with larger monolithic systems. Likewise, the popular Google Maps application which offers only a limited set of features out of the box but which provides an open programming interface enabling extension and adaptation has inspired many innovative and educational mapping applications. Such design

approaches, which assume that a large part of a technology's value lies in its capacity to be extended and combined with other applications, are worth emulating in open educational technology development. Design for agency encourages the development of smaller components and smart tools that clearly express what they do, rather that imposing how they should be used. Designing interoperable tools with personal agency in mind empowers individuals and institutions to build, adapt, and integrate custom educational solutions in a manner that best meets their needs.

Meeting Individual Needs The VUE project approached the principle of agency by first suspending assumptions as to how scholars prefer to work with digital resources. While a number of use cases guided the application's development, VUE is ultimately designed as a small and flexible tool for individuals and in support of individual needs. There was no single use case or imagined educational context around which VUE was designed. The design process recognized that while the central challenge of selecting, structuring, and personalizing digital resources en route to understanding is common to many, its precise form or expression is highly dependent upon individual teaching and learning preferences, specific educational settings, and working contexts.

For this reason, VUE was designed as a general-purpose utility. Its many features and functions, which are quite useful within formal educational contexts, are equally helpful outside of the classroom and in support of informal learning needs. This flexibility is pervasive in VUE and results in considerable user control. Rather than implementing VUE as an interface to a single digital library, the application is resource agnostic, designed to accommodate an ever-increasing range of digital information sources. The guided mapping described above is also designed to accommodate individual interests. Based on common standards such as RDF Schema and OWL for defining ontologies and CSS for styling the appearance of map objects, it allows for unbounded support of domains and educational activities. Finally, VUE has been designed as a portable client application to be owned and managed by individuals that does not require extensive or coordinated technical infrastructure and support.

Design for Ownership

The ability to literally own a technology or collection of resources is almost a given with open source software and content. Various licensing agreements adopted by producers of open educational resources permit users to acquire and adapt source code and educational materials to their liking. Designing for ownership assumes a future of educational resources assembled in part from the earlier work of many designers and developers. This approach anticipates that any given product may become part of a future application or resource and, in so doing, will become transformed into something quite different.

This proposition is not always easy to accept for designers of educational resources who contribute significant time and energy toward developing new tools. An important role for open education initiatives is to establish practices that reward the original creators of material with proper acknowledgement and that cultivate a sharing, global community that blurs the line between producers and consumers of open resources. As the supply of high-quality open technologies and resources increases, it is likely that producers of new educational tools will also be the direct beneficiaries of earlier efforts.

Designing for ownership is also closely linked to fostering individual agency and participation and the ability to define a technology in one's own terms. People are far more motivated to invest in adopting or extending an educational resource if they share in its ownership and evolution. Designing for ownership speaks to the importance of locality in determining a technology's use and meaning (Nardi and O'Day, 1999, p. 54). The opportunity for a group or individual to make a technology personally meaningful is to own it. Co-ownership and shared responsibility for a resource's development, a characteristic of so many open technology initiatives, is advanced by the most flexible software architectures and licenses. However, even with such provisions in place, an ongoing challenge for many projects is to maintain this degree of open ownership once a community has been defined, empowered and institutionalized.

To Modify Is to Own Ownership is often expressed through adaptation and modification. And as a modular and open source product, VUE lends itself to further refinement and extension by future developers. However, beyond making the code widely available, the VUE design

team built a number of the application's core components around the Open Knowledge Initiative software standards. By adopting common technical standards, owners of VUE may more easily extend the application and integrate those resources and repositories most meaningful to specific domains, tasks, and educational activities. VUE's standards-based design enables educators and students to incorporate an increasing variety of digital repositories and resources as needed. Further, offering various options for exporting VUE content maps in open formats has fostered adaptation and integration into numerous information management workflows and external systems.

On the surface, designing for ownership requires little more than adopting truly open licensing agreements which encourage future use, adaptation, and open sharing. In support of this goal, VUE 2.0 is licensed under Educational Community License. However, designers can make ownership more meaningful to future adopters by allowing for the easy decomposition of resources and technologies to fit an individual's environment and to enable new derivative works. This may involve creating, exposing, and documenting function-specific components in the case of educational software or allowing educators to extract a sub-set of educational content from an online course.

Design for Participation

If the design of educational technology facilitates broad access and fosters personal agency and ownership, participation in adopting and evolving a new application is likely to occur. The forms of participation in open educational technology presented here refer both to community involvement in developing or extending an educational resource as well as pedagogical designs which recognize the values of an individual's engagement with the educational resource itself: active learning. Thus, essential to the success of open education projects from the perspective of participation is the establishment of representative communities capable of informing the design process, designs which encourage contributions, and an understanding of the importance of active participation in learning. The broader question raised by this value is how open is the technology to participation in its development and use.

Community is readily associated with open technology, and there are many examples of open source projects that benefited greatly from

sustained, active communities. Participation in these communities, however, has largely consisted of those invested more in the technology's development than its use. Design and development processes that invite partnerships with intended audiences may lead to technologies that are highly accessible and oriented toward user action and control. Early experiences with *participatory design* involving the collaborative development of computer systems by managers, union workers, and technology designers provide models still relevant to today's open education initiatives. This design approach, originating in Scandinavia in response to broader social goals of democratizing the workplace, enlists intended users of a technology as active members of its design team (Ehn, 1993). Rather than simply identifying user likes and dislikes, such design practices take seriously user concerns and their existing environmental conditions.

More recently, an awareness of the degree to which social interactions among user communities influence technology development highlights the necessity of more inclusive design practices. Design practices that account for the social construction of technology by encouraging the participation of multiple user communities are emerging and inform open educational technology development (Gay and Hembrooke, 2004). Emphasizing inclusive design processes in no way minimizes the important role that purely technical choices play in enabling future participation over time. The benefits of open interoperability standards discussed earlier in regards to flexible technology integration apply to participation as well. Such standards permit external development communities to extend technologies to meet local needs and to advance the original product.

Another design consideration for those developing educational applications is provisions that encourage and support student participation and interaction—with each other and with educational resources. While not every tool used in support of the academic mission is directed toward learning, those that are will be more effective if grounded in educational practices that promote social and active learning (Bransford, Brown, and Cocking, 2000, p. 209).

Too often, however, many so-called open educational technologies are designed as unidirectional conduits for delivering more information faster, and therefore, fail to support the forms of student interaction,

engagement, and reflection necessary to advance understanding. By seeking the involvement of students, teachers, and instructional designers in the open design process, designers of open educational technology may create truly innovative, highly participatory applications that advance teaching and learning. Taken together, encouraging broad participation in the design process and prioritizing designs that foster active learner participation enables the positive transformation of both the educational technologies and the educational communities that adopt them.

Collaborative Design for Wider Participation The principles of design for participation have been a central part of the VUE development process. Concerning community involvement in VUE's design, over the course of the project faculty, students, instructional designers, and technologists have been invited to participate in design discussions and to review the application at various stages of development. Many of the features currently under development for VUE 2.0, including the presentation tools and ontology supported scaffolds, are in direct response to input from the academic community. The formal methods of soliciting participant input as part of VUE's design process are complemented by including additional menu options within the application to solicit feedback and to invite users to participate in online discussions. These options provide an easy mechanism for a broader audience of participants to contribute ideas and comments to the VUE project team.

Participation among technology developers has also been enabled by VUE's standards-based open architecture and flexible toolset. A number of organizations external to the VUE project team have adopted the Open Knowledge Initiative (OKI) standards as a means of making their digital content accessible through VUE and other OKI compatible software. To facilitate this activity, the VUE team, in collaboration with MIT's OKI project, established an online registry for developers to describe and post their digital repository modules. As a result, VUE users can query and install plug-ins to a variety of digital collections directly from within the application. Activity around these standards has been mutually beneficial, as VUE adopters gain access to a greater variety of digital resources, and content publishers offer their subscribers a

flexible tool for viewing, structuring, and managing their educational material.

Supporting Active Learning VUE is designed for participation from a student-centered, educational perspective as well. The tool's design encourages students to take an active, leading role in structuring, annotating, and manipulating digital content in support of their learning. Furthermore, these content maps are not digitally frozen, as are so many online resources. A VUE map created by an instructor to present key resources about a complex concept or topic may be downloaded and easily extended by students seeking to add their own resource nodes, links, and annotations. This form of active engagement with materials is critical to the learning process and assists students in personalizing and integrating new concepts and ideas. Designing for participation with learners in mind presents opportunities for VUE to move beyond simply making educational material accessible to providing information in a flexible format accompanied by tools that allow for further manipulation, extension, and refinement.

Design for Experience

Designing for user experience is usually the last consideration of many open educational technology projects. This is unfortunate, as a technology's look, feel, and the messages it conveys are as important to community adoption as is its depth of content and sophisticated functionality. Design for experience recognizes that all participants, particularly busy educators and students, quickly form opinions as to what resources are interesting, helpful, and worth their investment of time.

Design for experience is a form of human-centered design, an approach to technology with a long history. However, rather than focusing solely on the usability of a product, designers interested in the more affective qualities of their applications must also consider its appeal. "Does this tool attract attention? Is the experience of using the resource enjoyable and satisfying?" are questions that stem from designing for experience.

In *Emotional Design* (2004), Norman describes three styles of design that prompt or motivate user reactions to everyday tools. *Behavioral design* addresses the usability of a software application (Is the interface intuitive and effective?). *Visceral design* relates to an object's surface

appeal (How does it look and feel? Is it eye catching, attractive or repulsive?). *Reflective design* addresses one's satisfaction with a tool and the self-image its use projects. Taken together, these three styles of design influence our emotional response to technologies and acceptance or rejection of them. Norman concludes that attractive things simply work better. Tools that engage us and are enjoyable to use induce qualities of mind favorable to creative thinking and problem solving.

Open educational resources and technology have long been high on substance and low on appeal. However, it is this affective dimension of a tool, its attraction, that when combined with thoughtful instructional content and design motivates learners, capturing their attention and engaging the mind. One need only observe the considerable draw of video games and online social networking and role-playing environments to understand the potential of technology to engage an audience. Designing for experience recognizes the instructional benefit of creating open technology and resources that are at once substantive and attractive, compelling and a pleasure to use.

An Appealing Experience While VUE may not successfully compete for attention with today's most popular virtual gaming environments, great effort has been taken to design an attractive, appealing user interface (UI)—to design for experience. The VUE team dedicated considerable effort to reviewing the strengths and weaknesses of existing user interface models for managing and visualizing digital information.

Because available UI code libraries did not support the quality of user experience desired, additional resources were allocated to create custom interface components to accommodate VUE's specific requirements for user interaction. Attention was also dedicated to how maps look, feel, and function. What may appear to be small design decisions affecting only surface appeal actually serve to guide or scaffold clear communication and presentation of ideas using VUE. Such examples demonstrate the often hidden but nevertheless highly influential role of design in mediating educational activities, understanding, and experiences (Pea, 1991). Perhaps most importantly for the VUE project, the value of designing for experience was recognized early in the process and the role of designer was identified and established as an integral part of the

development team. Positive user feedback regarding VUE's ease of use and clear presentation of information suggests that this extra effort was justified.

Advancing Education

The purpose of working toward a theory of design for open educational technology is not to prescribe but to guide development practices. Recognizing that design matters, that the values and goals of open education can be either hindered or advanced through design choices, is the primary motivation for establishing design principles. Those presented here—access, agency, ownership, participation, and experience—provide a basic but generative framework for evaluating various design options for open educational technology. While it is impractical for any one application to meet all possible considerations stemming from these principles, the Visual Understanding Environment provides an illustrative example of how attending to even a few conditions extending from these principles can have a positive impact on the development of educational software. Given the current enthusiasm for and investment in open content and open technology initiatives, now is the perfect time to develop design methods that will deliver educational resources consistent with open values.

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