Teaching Boxes: Customizable Contextualized Digital Resources

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Abstract: DLESE Teaching Boxes are metaphors for online assemblies of interrelated learning concepts, digital resources, and cohesive narration that bridge the gap between discrete resources and classroom-specific inquiry-oriented lesson sequences. Currently, technology is being implemented that will support scaleable customizable teaching, creating opportunities for the use of the rich content within digital libraries in classroom teaching. Various pilot studies and workshops have been conducted to create teaching boxes as well as observe and analyze the process of teaching box construction.

Introduction

Teachers at both the K-12 and college course levels create compilations of lesson plans, activities, materials and other resources that they or other teachers have collected over time for different topics and grade levels. These materials, often stored in binders or boxes, are central points of reference as teachers decide what materials to use as stored, what materials to customize, or what new materials to employ in accordance with their teaching constraints. Possible constraints are time to cover a particular topic, student background, and compliance with state and national educational standards. Policies such as No Child Left Behind have increased the emphasis on meeting these standards, and teachers must find a balance between focusing on standards and enacting innovative and engaging curriculum in their classrooms.

Digital libraries support more targeted searches across subject-specific collections than the general internet search engines most teachers employ. The Digital Library for Earth System Education (DLESE – http://www.dlese.org), for example, contains Earth Science resources that are reviewed for scientific accuracy and linked to national science education standards. Using DLESE, teachers can access real-time data sets of earth science phenomena, lesson plans, images, multi-media resources, and other materials. How can we bridge the gap between these digital resources and customizable collections of teaching materials that can be localized for enactment in different classroom contexts? The "DLESE" Teaching Boxes project seeks to answer this question by providing scaleable and customizable digital analogs of the traditional teaching collections described above. Teaching boxes are classroom-ready lesson sequences that embed digital resources, encouraging the reuse of digital library resources. Teaching boxes emphasize the role of pedagogical context that supports customization by providing rationales behind lesson sequences and concept maps. In teaching box parlance, concept maps define the intended student progression through concepts and specify related national and state science education standards, maximizing the applicability of the main teaching box conceptual framework while allowing customizations to local teaching

The DLESE Teaching Boxes project grew out of a collaborative effort undertaken by DLESE, the University of Colorado at Boulder, University of California Berkeley Museum of Paleontology, San Francisco State University, United States Geological Survey, and San Francisco middle and high school science educators. This effort has lead to advancements in three areas: the construction of a "model" defining teaching boxes as knowledge constructs, the refinement of the collaborative workshop process for teaching box development, and the design and implementation of an application for creating and customizing teaching boxes. Below, we first describe the main components within a teaching box and then provide an overview of the feedback from teachers, design features and issues obtained from prior work. We then discuss current progress and intended directions for future work.

Teaching Box Main Components

The main structure of and views onto a teaching box emerged from teacher work and feedback during the 2004 California Pilot study. A teaching box consists of a list of digital resources in the teaching box, a concept map defining the progression of concepts for student understanding where concepts were related to educational science standards and learning goals, and sequences of lessons which were composed of activities for students. Digital library resources are embedded within the narratives describing activities for lessons. The teaching box overview page highlights grade level, prerequisite knowledge, and materials needed as well as presenting an outline of lessons to be taught. Teachers can use the overview page to evaluate the topic and scope of the teaching box and its relevance to their specific classrooms. They can then proceed to the different views and view or modify the different components to fit their needs.

Current teaching boxes seek to support student exploration of complex inter-related phenomena in Earth Science and understand these phenomena from an Earth Systems approach. Each teaching box tackles a particular set of Earth Science concepts that relate to national and state science education standards. The concept map lays out the intended student progression through these concepts, describing which concepts are prerequisites for others. The lesson sequence, a suggested sequence for inquiry-oriented lessons for classroom enactment, runs parallel with the concept map without necessitating a one-to-one correspondence. One lesson can help to teach multiple concepts and multiple lessons can refer to the same concept. Lessons include one or more activities, where activities refer to digital resources along with rationale describing how and why to use these resources. Through the activities described in the lessons, teachers guide students in discovering for themselves the scientific explanations for Earth Science phenomena, progressing through the concepts defined in the concept map.

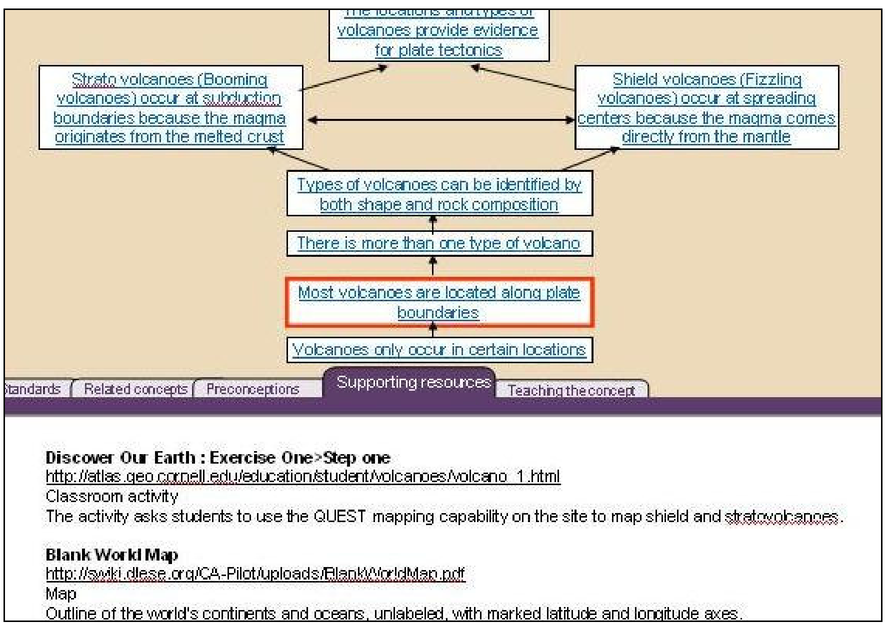

Figure 1: Concept Map and Related Resources for Plate Tectonics Teaching Box: Volcanoes.

The different views, concept map, lesson sequence, and list of resources, allow teachers to approach the teaching box according to their needs. They might be novice teachers new to this particular domain area and would thus benefit from starting with lesson sequences, viewing suggested methods of teaching as well as learning objectives and rationales for activities in lessons. Expert teachers may wish to review the list of resources first, assessing whether the resources and the activities that use these resources would be appropriate for their students and for their time constraints. The concept map can be helpful for all, delineating the conceptual framework underlying the teaching box as well as related science standards. Teachers can then concentrate on the fundamental learning objectives and incorporate standards into their teaching as opposed to teaching to standards.

Workshops, Studies, and Evaluations

The DLESE Teaching Boxes effort oversaw various studies and workshops which are described briefly in Table 1.

	Objective	Results
2004 CA Pilot Study (Workshop Series: Three Separate Workshops)	• Participatory design process • Define teaching box structure • Examine development process	• Emergence of 3 views: concepts, resources, lesson sequence • Teacher feedback on components • Designed and Implemented 2 Teaching Boxes: *Plate Tectonics, Dynamic Weather*
2004 UI Study (Three month-long design study)	• Design UI based on 2004 study • Develop prototype for Teaching Box • User studies based on prototype	• Prototype development and evaluation • Definition of core design issues and Teaching Box features
2005 Workshop (Workshop Series: Three Separate Workshops)	• Refinement of design process • Technology preview for collaborative design of boxes	• Feedback on collaborative design tool • Feedback on interface: Streamline, simplify • Designed and Implementing 4 Teaching Boxes: *Feeding Frenzy, Global Ups and Downs, Living in Earthquake County, Mountain Building*
NSDL Critique Lab	• Get feedback on specific UI elements	• Streamlined resource search and UI integration

Workshop: Teaching Box California Pilot

The DLESE California Pilot study (DLESE 2004) spanned three separate workshops which involved teachers as central participant designers and was mediated by pedagogical and scientific experts. Seven middle school and high school earth science and social studies teachers from the San Francisco area constructed two complete teaching boxes with the intent of implementing them in their own classrooms. These teachers formed two teams, with one team creating the "Evidence for Plate Tectonics" teaching box intended for the middle school level and the other team developing the high school level "Dynamic Weather" teaching box. After the workshops completed, scientific experts and workshop facilitators further reviewed the final teaching boxes for scientific accuracy and consistency. This study shed light on what components were required in a teaching box, the relationships between these components and the processes of constructing, utilizing, and modifying teaching boxes. Workshop developers used the task-centered iterative design approach to construct the final template, relying on teachers' suggestions and evaluations of components and teaching box mockups (Lewis et al., 1993). Although the template itself was a set of linear text documents, teachers engaged in a continuous process of review and revision. Observations of and interviews with teachers employing their or others' teaching boxes in their classrooms showed that teachers appreciated the need for and requested more pedagogical context (Garvin-Doxas et al., 2005)..

Study: Teaching Box Builder Pilot 2004

While the California Pilot study helped formulate the components within a teaching box and the teaching box development process, the Teaching Box Builder pilot study (Khan et al. 2004) explored the design issues in developing a web-based interface allowing teachers, regardless of prior knowledge of DLESE teaching boxes, to construct and customize teaching boxes. If teaching boxes are to become a widely used construct, supporting the use and reuse of digital library resources by middle and high school educators, we as designers must consider how to construct interfaces and enable navigation of these complex knowledge structures without encumbering time-constrained teachers. Although our pool of interview and think aloud participants was not large, this study yielded valuable insight into the need for supporting a dynamic iterative teaching box design process, the need for a personal collections system tying the teaching box repository of digital library resources with teachers' own existing materials, and the need to explore collaborative spaces for sharing and developing teaching boxes. The iterative task-centered design methodology (Lewis et al., 1993) was used to identify how our interface could facilitate lesson construction and constraint-based customization of teaching boxes. Having developed representative based on observations from the California Pilot workshops and the resulting boxes, we conducted semi-structured interviews were with 6 Colorado middle-school and high-school Earth Science teachers to explore lesson planning workflow, lesson modification, and teaching material reuse and modification. Participant experience varied from 2 years to 15 years in teaching middle or high school Earth Science and related subjects. From 5 of our interview participants, we also received feedback regarding the mockup displaying the Volcano area in the Plate Tectonics teaching box. On the basis of what we had learned from our interviews, analyses of related lesson planning systems, such as the Instructional Architect (Recker et al. 2001) and Lesson Plan Builder (Georgia Department of Education and Georgia Learning Connections), and our task statements, we identified the design priorities for our application, the Teaching Box Builder: the need to support dynamic iterative teaching box development without overwhelming teachers with a complex interface, a method for managing a personal collection of resources, and the need not only to display the three main component-views onto the teaching box but also to guide teachers through the relationships between these views.

These design issues drove creation of our high-fidelity prototype which we developed after evaluating 3 low-fidelity prototypes using the Cognitive Walkthrough method. The high-fidelity prototype used the content from the Volcanoes area of the DLESE "Evidence for Plate Tectonics" teaching box and used Java Swing to implement a split-plane view of teaching box content with components in the left pane and current navigation view in the right. Teachers could add and remove resources from a personal collection from which resources could be directly associated with lessons and concepts. Modifying relationships between components would prompt the appearance of dialog boxes explaining that the components being modified were related to other components. Our prototype supported iterative modification by making the resources, concepts, and lessons accessible on the same level through the use of tabs. For the Think Aloud (Lewis et al. 1993) evaluations of our high fidelity prototype, we selected 4 participants who had familiarity with plate tectonics concepts to ensure that our results were not confounded by a lack of understanding of the earth science content in the teaching box. We gave these participants tasks for adding or modifying lessons, resources, and concepts and the relationships between them. Our Think Aloud results showed that although our prototype had succeeded in breaking the teaching box content into separate but related components, teachers required both a view of the individual components and of the relationships and dependencies between components in order to assess the relevance of the lesson approach, the concept progression, and resources for activities for their own classes.

Workshop: DLESE 2005 Teaching Box Workshops and related Teaching Box Builder

A second series of workshops was held in 2005, resulting in four new teaching boxes with each teaching box covering about 2 to 3 weeks of instruction. Eight teachers, two scientists from the United States Geological Survey, and facilitators and Teaching Box Builder designers worked together to construct teaching boxes and explore design issues for teaching box construction and modification. Teaching Box Builder studies for this workshop concentrated on observing the actual process used by teachers in teaching box construction and on gathering teacher feedback on the design of the Teaching Box Builder application. We set up a Plone (see Plone) workshop website (see DLESE 2005 Teaching Box Workshop website) to support teacher brainstorming and document creation during the teaching box workshops. We found that the threaded forums on the Plone workshop website were too complex for use by teachers, but teachers adopted the use of editable online documents (similar to Wikis but including word editing capabilities) to record information about digital resources they found of interest. We also observed that, before filling out the teaching box template, teachers created "intermediate" documents that loosely defined relationships between concepts, resources, and activities. We also constructed a prototype based on Plone that allowed the creation of lessons, resources, and activities using the Plone content type creation paradigm where teachers could fill out a form defining these components. The focus group session on the prototype revealed that teachers found overwhelming this approach to component definition.

UI Evaluation: 2005 NSDL Critique Lab

In developing the requirements for the Teaching Box prototype, we evaluated some additional design features during the 2005 NSDL Critique Lab (see NSDL 2005). During this evaluation, we tested the use of in-context resource insertion. From previous feedback, we developed the notion that educators were interested in easy access to selected resources while they were developing the details of the Teaching Box. In this prototype, we provided the ability to use a menu attached to the right-click button to open up the website for a digital resource or associate a resource with an activity while a teacher was on the page for editing an activity. Each of the 7 participants in this lab was asked to perform an activity development task using preloaded resources made available to them within the prototype interface. They were given about 15 minutes to complete the task and were then asked to provide feedback on their experience completing it. Preliminary feedback revealed that participants overwhelmingly found the in-context resource insertion a useful feature. Furthermore, suggestions for an outline feature for the activity development task and a preview button were made. While this evaluation was based on limited feedback from a small group of participants, it nonetheless provided additional data points for consideration in the evolving design of the Teaching Box and the supporting tasks. In the next round of evaluation, we expect to test our new prototype on a larger group that focuses on our target audience.

Current Work and Conclusion: Design Issues, Architecture and Implementation

The ongoing development of the Teaching Box Builder application focuses on design desiderata that have evolved from the previous studies discussed above. The application should support iterative and dynamic construction and refinement of teaching boxes should allow teachers to specify and modify the different components (e.g. lessons, activities) as well as their relationships, should support the collection of resources that teachers find of interest in the context of the teaching box, and should support brainstorming and the recording of ideas and information. For example, teachers should be able to should be able to record potential ideas for activities without having to fill out all the fields required for the activity component in its final teaching box form. In the same vein, the application should allow teachers to record and annotate resource context, for example, recording notes for potential uses of a resource in a teaching box. The application should provide scaffolding in the form of guides and prompts analogous to the guidance provided in the teaching box workshops by teaching mentors (e.g. "how does this activity help to teach a concept from your concept map?") The application should streamline the migration from one teaching box development process to another, and finally the application should also allow teachers to associate and view the connections between concepts and the teaching box as a whole with both national and regional state science education standards.

Our current work advances the Teaching Boxes development prototype to explore features to support the collection and manipulation of digital library resources within the Teaching Box itself. In developing the prototype we are faced with several overarching requirements : (1) the system must support the underlying model of the Teaching Boxes prototype that would include support for the notion of objects, hierarchy and relationships among objects within the box, (2) the system must be service-based, for example, it must be accessible as a service so that the design of the front-end user interface is separated from the development of the functionality to be provided by the service, and (3) the system must provide the ability to connect to multiple, heterogeneous online repositories and digital libraries, from which most of the teaching box resources will be extracted. While these concerns do not represent all of the system requirements, they are the most important in the early development of the application, its features and architecture.

We have begun the initial design and implementation of the system to support these requirements based on the FEDORA framework (see http://www.fedora.info). The FEDORA object repository provides all of the functionality required to integrate the Teaching Box model into the repository, to utilize the underlying features of the framework as a service-based application through both a web-based SOAP protocol and a programmatic API to connect to repository, and allows seamless connectivity to external digital libraries, from which resources can be wrapped and repurposed for direct use in the Teaching Box model and hence the end-user application (Payette et al. 1998). One of the most significant implications of our current work is that it provides a window into the requirements for future projects that aim to achieve similar results. As the number and quality of online resources provided through digital libraries increases, the need to develop architectures, techniques and tools to access those resources to make them more useful for specific educational application use will continue to grow. We expect that the results of our work with FEDORA and the development of our own application service for Teaching Boxes will yield significant gains in this area, particularly for the development of educational applications for direct use of curriculum development.

Our initial results in tying these technology requirements back to the core tasks of the Teaching Box are encouraging. Since relationships among objects in the Teaching Box are important to the overall development of the contents within it, end users are given access to implicitly and explicitly create relationships among resources and the activities which they enhance. The services currently in development allow the underlying model and such relationships to be stored, rearranged and later retrieved. Similarly, since the development of the initial prototype began well before the development of the services layer of the current architecture (Teaching Box Application Web Service), separation of user interface concerns from core representations within the service and repository layer was necessary. With the current architecture, we may now support multiple interfaces to address the specialized concerns of identified stakeholders and feature sets. For example, content administrators may be presented with a different interface of the system than educators. Additionally, it may be important in lesson development to restrict view of certain resources that may be more relevant to students in specific geological regions. Finally, since the development of digital library resources is not restricted to any individual digital library, providing the functionality to access any digital library resource on the web anywhere allows teachers unlimited access to those resources that best fit their objectives.

Teaching Boxes represent multiple opportunities for research in education: (1) as professional development vehicles for teachers whereby novice educators can collaborate with more expert educators, (2) as collaborative design environments where educators and scientists create engaging, inquiry-oriented, and scientifically accurate activities for their students, and (3) as a platform for exploring online lesson plan development and teaching box development applications that can support sharing and customization. Understanding how real teachers plan and customize teaching boxes can yield valuable insight into the design of applications that can integrate into everyday teaching practices. The Teaching Box development process treats teachers as central participatory designers of the process and the application, increasing the likelihood that the Teaching Box Builder design will address the concerns of real teachers sharing, customizing and repurposing rich contextualized digital resources.

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