Software Solutions for Science e-Education: A Case Study from the VISIT Project*

Yichun Xie, Professor and Director
Institute for Geospatial Research and Education
Eastern Michigan University

125 King Hall
Ypsilanti, MI 48197
Tel: (734) 487-7588
Fax: (734) 487-5394
Email: gis_xie@online.emich.edu

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Why do we conduct this research?

e-Education, using the web as virtual schools or classrooms and Internet as primary delivery mechanism, has increasingly captured the enthusiasm and fantasy of entrepreneurs, educators and students. Many e-Education software systems have been franchised. However, few of them have successfully taken advantage of current available online resources and Internet technologies, such as, easy access to a huge and interlinked network of scientific data, advanced graphical tools and computational power enabling educators and students to visualize scientific data and processes in ways that were previously impossible.
What have we done in this research?

This study focuses on the technological and pedagogical challenges to science e-Education, based on the lessons learnt in designing and implementing an online collaboratory - VISIT – Virtual Immersion in Science Inquiry for Teachers, sponsored by a grant from US National Science Foundation Teacher Enhancement Program.

• The paper examines weak spots of current e-Education software packages. The paper discusses key characteristics of successful e-Education for science educators.
• The paper presents new designs for enhancing science e-Education, including, vertical (in-depth) exploration of time-series data, horizontal (geographic) exploration of time-series data, user-collected data integration tool, and knowledge database construction tool.
• The paper also discusses future directions of enhancing science e-Education software design.
Observations of current e-Education software infrastructure

To large extent, current e-Education software infrastructure is a technological imitation of traditional classrooms. It has not taken advantages of the rich information in cyberspace and instructional and pedagogical potentials of the information and the information technologies.

*Fig. 1 Common elements of current e-Education software*

<table>
<thead>
<tr>
<th>Course syllabus</th>
<th>Instructor biosketch</th>
<th>Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbooks</td>
<td>Readings</td>
<td>Grade report</td>
</tr>
<tr>
<td>Discussion forums</td>
<td>Chat room</td>
<td>Email server</td>
</tr>
<tr>
<td>External links</td>
<td>Course map</td>
<td>Tools panel</td>
</tr>
</tbody>
</table>
Fig. 2 Course management tools of current e-Education software

- Registration tool
- Group manage tool
- Assignment tool
- Calendar
- Course setting tool
- Communication tool
- Resource link tool
- Drawing tool
- Grading tool
- Assessment tool
- Survey tool
- Sys admin tool
Key factors for a successful science e-Education

Most students and educators participating in e-Education concur that the practical benefits of Internet-based learning and instruction are self-paced study, life-long learning, instructor-led discussion, and peer-to-peer collaboration (Walker, 1998; Kirkby, et al, 2002). In addition to these salient features, a successful e-Education, from the science education point of view, should support *obtaining knowledge from progressively growing volume of online scientific information, and conducting inquiry-based authentic learning* (Hargis, 2001).
Increasingly accessible large volume scientific databases contain untapped knowledge about sciences. This information, if properly retrieved, organized and analyzed, can provide extremely useful materials to support inquiry-based learning. The outcomes can provide science educators and students with a competitive edge in teaching and learning sciences. However, the single biggest problem is that so much of this information is distributed across networks, and often continents (D.Min, et al, 2001). Readily access to online data has overwhelmed educators and learners with information. Therefore there is an urgent need to develop new tools and processes that can help transform data into knowledge, including, data mining and explorative analysis, knowledge database construction and meta-knowledge accumulation.
1. Vertical (in-depth) and horizontal (geographic) exploration of time-series data

The online vertical data exploration tool, called Profile Plot, was originally developed by Water on the Web research group (WOW, http://wow.nrri.umn.edu/wow/index.html), and enhanced by the Virtual Immersion in Science Inquiry for Teachers (VISIT) research group (http://www.webpolis.info/pplot/index.html). This package allows students to choose a lake, a water quality parameter, a visualization method (By Depth, By Time), and an observation time duration to analyze the changes of a parameter in vertical direction or in time-series (Fig. 3). Profile Plot can also be used to explore relationship between multiple parameters or compare spatial variations between different lakes.
Fig. 3 A screen of Profile Plot developed by the VISIT project
The Online DataView is a web based scientific investigation tool developed by the VISIT project (Fig. 4, http://maps.acad.emich.edu/dataview/). It is designed based on the Rouge River water quality database and the design of the Rouge River National Wet Weather Demonstration Project software package, DataView (http://www.wcdoe.org/rougeriver/). The water quality data sets and their associated phenomena can be analyzed from the perspectives of different disciplines and school science curricula, and by location (city/township and observation station – Search Location), by parameter (Search Parameter), or jointly by location and parameter (Query Builder). The Online DataView can explore relationships between multiple parameters or compare spatial variations between different locations in the map (Fig. 5), graphic, and table (Fig. 6) forms.
Welcome to Explore Water Quality Data Online
About || Search Location || Search Parameter || Query Builder || My Library || Search || User Database

**The Rouge River Watershed**, located in Southeast Michigan, runs through the most densely populated and urbanized land area in the state. The Rouge River has been classified as one of the most polluted rivers in the United States and in 1981 was designated an Area of Concern by the International Joint Commission because of its severely degraded condition and its impact on the Great Lakes.

The Rouge River National Wet Weather Demonstration Project (Rouge Project) is a watershed-wide program that is providing solutions on how to restore a polluted urban waterway. The comprehensive project published the RPO Dataview software, a Windows-based application, which can be used to retrieve rouge river water quality database on CD-ROM. Its database is a useful resource for the VISIT project.

Fig. 4 A screen of the Online DataView developed by the VISIT project
Fig. 5 Viewing data in the map form – Online DataView

Site ID: M3003690, in ALLEN PARK, Kingswood?

(Right Click on the map to zoom the map)

23 parameter(s) found.
Fig. 6 Viewing data in the table form – Online DataView

<table>
<thead>
<tr>
<th>SITE_ID</th>
<th>DATE</th>
<th>TIME</th>
<th>PARAMETER</th>
<th>VALUE</th>
<th>UNITS</th>
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</thead>
<tbody>
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<td>12:00:00 PM</td>
<td>CR_XRF</td>
<td>20</td>
<td>UG/G</td>
</tr>
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<td>12:00:00 PM</td>
<td>CU_XRF</td>
<td>12.4</td>
<td>UG/G</td>
</tr>
<tr>
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<td>12:00:00 PM</td>
<td>DEPTH</td>
<td>1</td>
<td>FEET</td>
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<td>1.9</td>
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<td>PB_XRF</td>
<td>18.9</td>
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<td>UG/G</td>
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<tr>
<td>D1003639</td>
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<td>12:00:00 PM</td>
<td>PCB_EIAWW</td>
<td>0.12</td>
<td>UG/G</td>
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<tr>
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<td>12:00:00 PM</td>
<td>SB_XRF</td>
<td>2</td>
<td>UG/G</td>
</tr>
</tbody>
</table>
2. User-collected data integration tool

There are many reasons for using the Internet to conduct science education. Some principal incentives are its ability to engage students as active participants, the motivational influence of Internet-based authentic learning activities, and the ability to include student inquiry and cooperative learning in Internet-based lessons. However, the ability of e-Education software that allows students (learners) to upload their own field observation data and to conduct comparative studies with achieved data is a critical technical prerequisite for all of these feats.

The Online DataView package contains a tool set called, *Databases*, which supports the integration of users’ data with the online achieved data and the comparative authentic inquiry (Fig. 4). When a student clicks Database, a screen of data uploading instruction is opened (Fig. 7).
Databases

Users can view data from two of DataView’s Databases: System Achieved Database and Special User Database. The System Achieved Database is the Water Quality Database created by the Rouge River National Wet Weather Demonstration Project and read-only. Users can upload self-collected data (in text file format) into the Special User Database.

- If you want to upload your own data, click here.
- If you want to select a database to view, click here.
**Fig. 8 User File Upload Form in Online DataView**

### File Upload Form

Users can upload self-collected file to the Special User Database. The user file is formatted into a comma (tab) delineated text file. The file should look like the following:

<table>
<thead>
<tr>
<th>TName,</th>
<th>SITE_ID,</th>
<th>PARAMETER,</th>
<th>Date,</th>
<th>TIME,</th>
<th>VALUE,</th>
<th>UNITS</th>
<th>USER</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORTHVILLE TWP., D1003002,</td>
<td>RAIN,</td>
<td>4/1/94, 1:00:00 PM,</td>
<td>2, IN</td>
<td>Yichen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NORTHVILLE TWP., D1003002,</td>
<td>RAIN,</td>
<td>4/1/94, 1:00:00 PM,</td>
<td>4, IN</td>
<td>Yichen</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please fill in the file-upload form below,

**File to upload:** ________________________________

**to upload the file!**
3. Knowledge database construction tool

Another interesting experiment of the Online DataView is the tool called, *Save to My Library*, which is actually a tool for constructing knowledge database. When a user is conducting data analysis through *Query Builder* in the Online DataView, the query results will be reported along with a button, *Save to My Library* (Fig. 9). This option button calls the Knowledge Database Construction Dialog (Fig. 10).

*Fig. 9 Conducting Data Analysis through Query Builder in Online DataView*

**Query Result:**
137 Site(s) found according to criteria(s):
(parameter='DO' and value>7.0) or (parameter='WTRTEMP' and value>40)

Date range: 1/1/1995 - 12/31/1999
Township: and TNAME = 'CANTON TWP.'
Yichun Xie: more about the query you made.

<table>
<thead>
<tr>
<th>Query Title</th>
<th>Relation between DO and Water Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query Description</td>
<td>The query was done on April 28, 2001 to develop a lesson plan for environmental science, demonstrating how to use online spatial data analysis and knowledge construction tools to assist inquiry-based learning.</td>
</tr>
</tbody>
</table>

**Query Type:** Multiple-criteria query and spatial pattern in map.  
**Township:** and TNAME = 'CANTON TWP.'  
**From Date:** 1/1/1995  
**To Date:** 12/31/1999  
**Query criteria:** (parameter='DO' and value>7.0) or (parameter='WTRTEMP' and value>40)
Discussions

The design and development of science e-Education are complex undertakings. This is partly because the cyberspace is experiencing dynamic evolution. Increasingly more and more scientific data and materials are available to educators and students. Another part of the reason is that the development process involves many interrelated elements that must work in unity to form a coherent system for learning. Each of the elements is critical to the success of the science e-Education and the learning experience that the student receives. In short, the challenges we are facing can be clustered into two dimensions: data mining and exploration for data to be transformed into knowledge; and pedagogical alignment with educational standards and benchmarks for creating a new online learning environment.