J 4.1 **LEAD EDUCATION INITIATIVES**

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1. INTRODUCTION

As collaborative partners in Linked Environments for Atmospheric Discovery (LEAD), Millersville University and Howard University, along with several other LEAD education testbeds, are responsible for the evaluation and assessment of LEAD technologies, and the development and dissemination of educational materials and services to the wider education community. Toward this effort, Millersville University is collaborating with other LEAD partner institutions to extend several existing tools such as Unidata's Integrated Data Viewer (IDV) and NASA JPL's SWEET ontology for LEAD educational initiatives. Furthermore, IDV is utilized in the design and development of LEAD-To-Learn modules through the inclusion of IDV bundles and also as a way to allow student interaction and visualization of various data types. IDV and some of the educational materials developed in conjunction were also used in Howard University's Weather Camp in the summer of 2005. The following sections describe each of the above initiatives in more detail.

2. IDV AND LEAD

Unidata's IDV is a Java-based software system for analyzing and visualizing geoscience's data (Murray, et al, 2005). The IDV provides similar standard data displays to other Unidata software such as GEMPAK and McIDAS but also allows users to interact with data in 3-D views, cross-sections, profiles, and animations. The unified interface gives the user the ability to analyze many types of data such as; gridded data (numerical weather prediction model output), satellite imagery, NWS WSR-88D Level II and Level III RADAR data, surface observations, balloon soundings, and NOAA National Profiler Network data.

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Undergraduate students at Millersville have been involved in developing interactive modules and other learning materials utilizing IDV. As a first step, Undergraduate students have developed an IDV beginner's tutorial that is specifically designed for pre-college educator and student users. The tutorial explains the different data types (gridded, satellite, etc.) that can be viewed in IDV and how to select these types of data. The tutorial also contains information on different display fields (3-D, cross-section, etc.), various window options, and toolbars. This section also guides the user on how to change color, transparency, and values of variables being displayed as well as saving bundles and pictures. Furthermore, the tutorial includes a set of exercises after every section. These exercises instruct the user on how to make, modify, and save an IDV bundle. As an example, by the end of the tutorial, the user would be able to have a contour view of mean sea level pressure, along with a 3-D isosurface of wind speed. The user will interact with the data as well as be able to change options such as the color of the 3-D surface, the value of the surface, and the transparency. The exercises cover the most basic ways the user can interact with the data, and provide an opportunity to experiment with the visualization tool.

Another use of the IDV is in LEAD-To-Learn modules through the development of IDV bundles. Undergraduate students and LEAD teacher partners have been involved with the development of modules for two different educational levels. These modules allow students to interact with and visualize output from the NAM and WRF numerical models, and other data types, while learning other related meteorological concepts. The modules include static information about a particular topic as well as guidelines on the use of IDV and IDV bundles to enhance the student understanding of the topic. IDV bundles are information files that specify the state of the IDV and contain information about data sources, parameters, and the display mode of the parameters. Undergraduate students at

Millersville have been directly involved in creating IDV bundles that serve as a basis for the visualizations within the LEAD-To-Learn modules. IDV bundles allow students to interact with data and learn about specific features and characteristics of an event. To date, the following bundles have been created by Millersville undergraduates:

- Temperature Inversion
- Fronts
- Jet Stream
- Observations-to-Models
- Lake Effect Snow
- Stability
- Temperature Gradients
- Vorticity

A common template has been constructed for the modules that includes: introduction, learning goals and objectives, background, related terms and vocabulary, exercises (with added links to answers), and an appendix. Each module also has a question section to assess student's grasp of the materials before moving on to another section. Work is currently underway to design a formal assessment rubric for the modules. An example of these modules can be found on the LEAD Education and Outreach Website (http://snowball.millersville.edu/~lead). Some of the materials designed and developed by undergraduate students at Millersville were used for instruction at Howard University's Weather Camp in the summer of 2005. The simple IDV tutorial and IDV bundles were used by the high school students attending the Weather Camp. Plans are already in place to extend the use of IDV beyond the use for enhancing the instructional materials and to make it available to students for investigation and case study work.

3. THE LEAD ONTOLOGY

Generally, an ontology is a formal, explicit specification of a shared conceptualization (Gruber, 1993). Closer to the discipline, Robert Raskin, principle developer of the Semantic Web for Earth and Environmental Technology (SWEET) defines an ontology as a formal representation of technical concepts and their interrelations in a form that supports domain knowledge" (Raskin, 2003). For our purposes in LEAD, it is a database of concepts and relationships invented to subcategorize terms based upon their specific and essential qualities. An ontology is agglutinative (new terms can be formed by combining existing terms) and semantic (the meaning of terms is formally specified {machine understandable}). LEAD comprises a complex array of services, applications, interfaces and local and remote computing, networking and storage resources –so-called environments– that are assembled by users in workflows to study mesoscale weather. The LEAD ontology is being developed as a Service that is intended to help the user engage in the following fundamental capabilities: a) Query for and Acquire a wide variety of information including but not limited to observational data sets (including real time streams) and gridded model output stored on local and remote servers, definitions of and interrelationships among meteorological quantities, education modules at a variety of grade levels that are designed specifically for LEAD, and b) Analyze and Mine observational data and model output to obtain quantitative information about spatio-temporal relationships among fields, processes, and features.

The LEAD ontology also serves as a key technical requirement for functionality by providing a service for the data sub-system that a user can employ to: a) Determine or define the data needed to complete a pre-determined task as part of experiment design by making advanced use of ontology catalogs, accessible through the LEAD Portal, during experiment construction, Understand difference among data types by providing interoperability, b) between the ontology service, which resolves relationships among variables, and the dictionary/glossary, and c) Locate data based on quantity, location, phenomena, physical property, substance, and instrument using the ontology catalog for single point query access based upon user-specified high-level attributes. Since LEAD in focusing on mesoscale events, the effort at Millersville has been focused on building the LEAD ontology for mesoscale structures. The LEAD ontology builds on the Semantic Web for Earth and Environmental Technology (SWEET) developed at NASA-JPL by Rob Raskin (2003) and others. The LEAD ontology is a granulation of SWEET for mesoscale structures. It uses the same concept space, enables scalable classification of mesoscale concepts, and serves as an electronic encyclopedia for learning by discovery. However, unique to the LEAD ontology is the inclusion of a glossary/definition of terms – a dictionary, added with the expressed intention to facilitate discovery and to serve as a "help" function for educational users. Since the LEAD ontology is an extension of SWEET, the nature of orthogonal and unifying concepts preserve the users' ability to emulate the types of scientific investigation: reductionism and holism. And like SWEET, the LEAD ontology enables science knowledge/resources to be organized by Realm, Phenomena, Physical Property, Substance, Spatial Entity, Numerical Entity, Temporal Entity, Services, Data Services, and Units. LEAD will be adding sensors and instruments to the ontology. The LEAD goal is to create a topology linking key concepts in mesoscale meteorology, with each concept representing a taxonomy. The LEAD ontology will be wrapped as a Web Service at the University of Alabama-Huntsville, and will be accessible via the LEAD Portal for query, info-mining, and resource cataloging of data and services, as an educational service, a knowledge resource, and community reference. In addition, the LEAD ontology will become essential service in the development of a dynamically adaptive learning environment for students and teachers. One way to utilize the semantic information encoded in the ontology is through the LEAD Portal. Submitting a query from the portal invokes the ontology inference service which reasons upon the ontology. The ontology does not return a simple definition, although it can. Instead it associates the term with the data, services, physical properties and/or phenomenon in the same concept space.

While the primary responsibility for building the LEAD ontology falls on the research and development efforts at University of Alabama-Huntsville using OWL as the W3C standard and SWEET-like LEAD semantic tags, undergraduates at Millersville University took on the task of expanding the SWEET ontology to include a vocabulary of mesoscale quantities. To date, undergraduates have added 560 mesoscale terms organized by Standard Name (quantity), LEAD Realm, Phenomena, Physical Property, Substance, Space, Numerics, Time, Services, Data, and Units. In addition, definitions for each quantity were taken from the American Meteorological Society Glossary of Meteorology (AMS, 2000) and are included with the vocabulary.

Over 560 standard names have been added to the SWEET semantic tags to create the LEAD ontology. These names are limited to an alphabetical listing of mesoscale meteorological phenomena, including several quantities in other spatial regimes (e.g. climate, synoptic, boundary layer, microscale). But the vocabulary is incomplete. Currently, a group of five undergraduate students at Millersville are working to expand the LEAD ontology to include standard names relevant to numerical weather prediction, data assimilation, instruments and sensors, and data types. As sections are completed, the vocabulary and glossary will be sent to UAH where the ontology will be written in the OWL ontology language and wrapped as a Web Service. We expect a continuation of this vocabulary building process to continue for the remainder of LEAD.

4. SUMMARY

Significant advancements in the development of interactive IDV bundles, tutorials, and other LEAD-driven educational materials have been accomplished. Undergraduate students at Millersville have developed a suite of interactive IDV bundles, and are working on developing additional modules such as mesoscale radar signatures, and squall lines among others. Work continues on the expansion of the SWEET ontology that involved involves physical quantities, realms, numerics, phenomena, physical properties, space, physical substances, time, units, and dataset properties for finding class and sub-class relationships for nearly 1000 quantities. In addition to and different from the SWEET ontology, the LEAD ontology includes a glossary of definitions for each quantity so that it can be utilized later for use in the modules developed in conjunction with the LEAD portal. Furthermore, LEAD teacher partners will be involved with the design of a simple version of the glossary that will be included in the modules for pre-college students and will be incorporated into the basic portal.

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