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Organization: Concord Consortium
Submitted By:
Horwitz, Paul - Co-Principal Investigator
Title:
Logging Opportunities in Online Programs for Science (LOOPS): Student and Teacher Learning

Project Participants

Senior Personnel

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Worked for more than 160 Hours: Yes
Contribution to Project:

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Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Horwitz, Paul
Worked for more than 160 Hours: Yes
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Name: Slotta, James
Worked for more than 160 Hours: Yes
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Worked for more than 160 Hours: Yes
Contribution to Project:
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Contribution to Project:
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Worked for more than 160 Hours: Yes
Contribution to Project:
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Undergraduate Student

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Other Participant

Research Experience for Undergraduates

Organizational Partners

University of California-Berkeley

The UC Berkeley team is primarily responsible for carrying out the research in schools and for facilitating and supporting implementation of the treatment.

University of Toronto

The University of Toronto team is collaborating with Concord Consortium staff on technology development.

Other Collaborators or Contacts

Partner schools and Teachers
Glenbrook MS, Mt. Diablo USD: Concord CA, Mike Marshall
Valley View MS, Mt. Diablo USD: Pleasant Hill, California, Matt Hesby
Martinez JHS, Martinez USD, Lauren Norse & Jefferson Hartman
Albany MS, Albany USD, Eric Mapes & Marty Place

Other collaborators or contacts
Consultants - Jeffrey Schoonover Curriculum Developer
Barbara Buckley Project Evaluator

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings:

Training and Development:

Outreach Activities:

Journal Publications

Slotta, J. D. & Jorde, D., "Learning from our peers in international exchanges: When is worth doing, and how can we help it succeed?", The International Journal of Science Education, p. , vol. , (2008). Accepted,

Tinker, R., & Xie, Q., "Applying computational science to education: the Molecular Workbench paradigm.", Computing in Science and Engineering, p. 24, vol. 10(5), (2008). Published,

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Gerard, L. F., Bowyer, J. B. & Linn, M. C., "Principal Leadership for Technology-Enhanced Science", Journal of Science Education and Technology, p. 1, vol. 17(1), (2008). Published, Gerard, L., Bowyer, J., & Linn, M. C., "Scaling Technology-Enhanced Science Curriculum: Leadership Development in a Community of Principals. In International Perspectives in the Learning Sciences: Creating a Learning World.", Proceedings of the 8th International Conference of the Learning Sciences Utrecht, The Netherlands, p. 35, vol. 3, (2008). Published,

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Reiser, B, "Designing Coherent Science Education", (2008). Book, Published
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J. & Fischer, F.
Bibliography: Classroom of the Future. Orchestrating
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of atomic-scale phenomena and
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Bibliography: Paper presented at the AAPT Annual
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Tinker, R., "Perspective: The Concord Consortium
vision", (2008). @Concord Newsletter, Published
Bibliography: @Concord, 12(1), 2-3

Tinker, R., & Bell, K., "The Center for Enhanced Learning of
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Micro and Macro", (2008). Paper presented at the NSTA National Conference, Published
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A., "Chemistry visualization and student
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Linn, M., Varma, K., Husic, F, "Examining the Role of Teacher Partnerships in Science Education Research,
Professional Development, and Teacher Learning", (2008). Book, Published
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Bibliography: Wallenberg Global Learning Network,
Lund University, Sweden, April 1, 2008

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and Online Guidance to Bring Learning to
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2008, 21st Century Learning @ Hong
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Campus, Hong Kong, May 3, 2008

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Bibliography: Center for Information Technology in
Education (CITE) 10th Anniversary
Seminar, University of Hong Kong May
14, 2008

Linn, M., "Technology and Science Learning", (2008). Presentation, Published
Bibliography: Guangxi Normal University, Guilin,
Guangxi, China, May 5, 2008

Web/Internet Site

URL(s):
http://loops.concord.org/
Description:
LOOPS home page on Concord Consortium site

Other Specific Products

Contributions

Contributions within Discipline:

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Activities and Findings: Any Findings
Activities and Findings: Any Training and Development
Activities and Findings: Any Outreach Activities
Any Product
Contributions: To Any within Discipline
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering

LOGGING OPPORTUNITIES IN ONLINE PROGRAMS FOR SCIENCE (LOOPS): STUDENT AND TEACHER LEARNING

ANNUAL REPORT 2008

ACTIVITIES

The goal of the LOOPS project is to use the cyber infrastructure to provide resources that support inquiry in the middle school science classroom. The project will make innovative use of technology to create timely, valid, and actionable reports to teachers by analyzing assessments and logs of student actions generated in the course of using online curriculum materials. These reports will enable teachers to make data-based decisions concerning alternative teaching strategies.

The project is a collaboration of the Concord Consortium with a research group at the University of California, Berkeley, and another group located at the University of Toronto. In order to coordinate the efforts of these remotely-situated teams, during the first year of the project we organized six face-to-face meetings, at Concord and at the other two locations, and we have held conference calls every two weeks. Below, we report on the activities of each participating team separately.

ACTIVITIES AT THE CONCORD CONSORTIUM.

In addition to its responsibility for the overall management of the project, the Concord Consortium's main role has been to design and implement the infrastructure technology required to make it a success. In accomplishing this goal, we have adapted and enhanced the SAIL (Scalable Architecture for Interactive Learning) technology developed by the TELS Center on a previous NSF GRANT # ESI0334199 October 2003 to August 2008 Paul Horwitz PI

The Concord Consortium has also played an important role in curriculum development, based on the California 8th grade science standards for the two curricular strands of the project: Force and Motion, and Chemical Reactions.

Following the California science standards for the 8th grade, we started by describing 10 modules, covering:

1. Vector position
2. Position-time graphs
3. Velocity-time graphs
4. Velocity in one and two dimensions
5. Forces
6. Separation of forces
7. Force and motion in one dimension

8. Force and motion in two dimensions

9. Gravity

10. Projects

For each of these modules, we identified the standards that the module addressed, the software or other technology that would be required to run it, the nature and purpose of the classroom discussions that support it, the investigations students would be expected to undertake, the extensions to the module that could be introduced, time permitting, suggested lab activities, and how student learning was to be assessed.

With these modules in hand, and advances made on the technologies necessary to support them, we have more recently been engaged in creating teaching and lesson plans that cover the first 3 weeks of an expected 6-week curriculum in force and motion. These materials cover position-time graphs in one dimension, velocity-time graphs in one dimension, and motion in two dimension, all treated from a purely kinematic point of view - in other words strictly as descriptions of motion with notions of causation (e.g, forces) ignored. The second three-weeks, not yet completed, will deal with forces.

In all of our curriculum development we are emphasizing particularly the "loops" - i.e., the feedback and reporting mechanisms - that we intend to build in. Thus, for example, in introducing position-time or velocity-time graphs to students we intend to make use of our Smart Graph technology, which can automatically identify such features as inflection points, monotonic regions, maxima and minima, and so forth, on a graph, whether it is produced by real-world or model data, or drawn by a student. This enables us to comment on the students' work, scaffold their efforts, and report on their success or failure at specific tasks.

DEVELOPMENT OF LOOPS TECHNOLOGICAL INFRASTRUCTURE

The essential goal of the LOOPS project technology is to:

- Enable deployment of meaningful pedagogical LOOPS in classrooms.
- Integrate the authoring of the curricular activities and the reports and possible actions that make up the LOOPS.

In order to support the researchers, curriculum authors, and teachers in this project as they wrestle with creating and evaluating new forms of LOOPS it is critical to add authoring and customization of LOOPS themselves to the existing extensions the LOOPS project is making to SAIL/OTrunk authoring. By making this integration the authors of activities will be more likely to create both new forms activities which generate meaningful data for creating LOOPS, as well as variations on existing forms.

The technical development for the LOOPS project is ambitious however there are several other projects that have and are continuing to contribute to the technology base.

SAIL/OTrunk Background

The TELS project which ended in September 2008 contributed greatly to the development of the SAIL/OTrunk framework on which the LOOPS development is based.

SAIL stands for the the Scalable Architecture for Interactive Learning[1]. The most recent versions of SAIL have been integrated with Concord Consortium's OTrunk framework[2].

There are two key ideas in SAIL/OTrunk. One involves and architecture for assembling reusable, pedagogically-aware Java components into curricular activities. These rich components already include:

- Computational models with rich visual representations. These include, among others, molecular dynamics and biological models.
- Graphs for displaying both real-time and saved data.
- Sensor collection components for collecting and graphing real-time data from sensors as well as analyzing data collected previously.
- Drawing tools that support a range of formats from a simple bitmapped painting, to object drawing, to concept mapping.
- Models written in general purpose-modeling languages such as NetLogo.
- Assessments ranging from multiple-choice to open-response text input.
- Components that can render web content ranging from html, css, to flash and QuickTime. While browsers are capable of this, there are many times in which web content may need to be delivered in a more constrained environment which does not necessarily allow browsing to other sites.
- The integration of the many forms of web content and interaction with the more powerful modeling and analysis tools that are available in Java to deeper learner exploration and inquiry and the creation of both richer explicit and implicit learner artifacts.

The second key idea is that SAIL delivers these components a network-enabled pedagogically-aware persistence service that lets the components load and save learner data. The underlying SAIL architecture takes care of storing a complete revision history of what has been saved and also makes sure that the data are associated with the correct student, workgroup, class, and teacher. This persistence is supported by the core SAIL framework that is included with the client application and the SAIL Data Service (SDS) web service.

OTrunk has been developed at CC to connect arbitrary objects that can be imagined as being pulled out of a trunk. This section briefly describes the major SAIL components currently supported with OTrunk interfaces. Any one or combination of these objects can be used by the editors to create learning activities.

We have created several OTrunk activity editors that can allow materials developers to combine components into complete learning experiences, which we call SAIL learning activities. The activities that are produced can start life as blanks or recycled activities.

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1 http://www.telscenter.org/confluence/display/SAIL

2 https://confluence.concord.org/display/CSP/OTrunk

The editors reflect the specific needs of different projects at CC and the growing capacity of the software.

The LOOPS project is extending work on SAIL/OTrunk WYSIWYG authoring and smart graphs being implemented by Concord Consortium's UDL project for elementary science. This WYSIWYG editor uses a “flow” metaphor, permitting rich objects and formatted text to be intermixed on the page. In this editor, large objects such as models and graphs, are treated on the page as text would be. Figure 1 illustrates this editor with an example of the OTrunk authoring system being used to author a page which has an embedded graph. The author in this case has added an initial dataset by using the pencil tool.

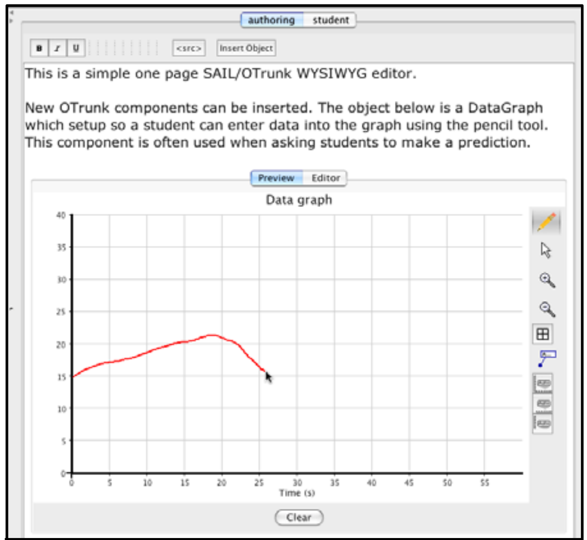


Figure 1: A WYSIWYG editor. In this example, the author has inserted some text and a graph object

Figure 2 shows the embedded graph being changed into one that now collects data from a temperature sensor.

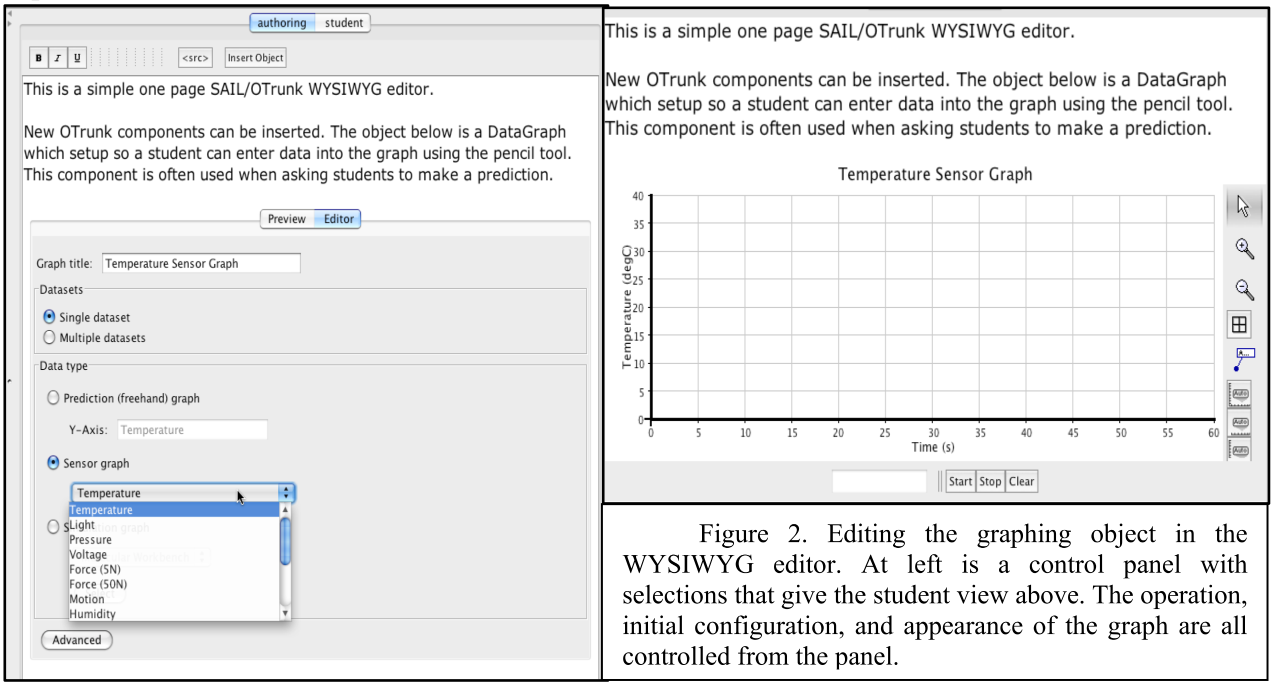


Figure 2. Editing the graphing object in the WYSIWYG editor. At left is a control panel with selections that give the student view above. The operation, initial configuration, and appearance of the graph are all controlled from the panel.

For a more detailed non-technical description of existing SAIL/OTrunk capabilities see this pdf document: A Brief Description of the SAIL Environment by Bob Tinker and Stephen Bannasch[3].

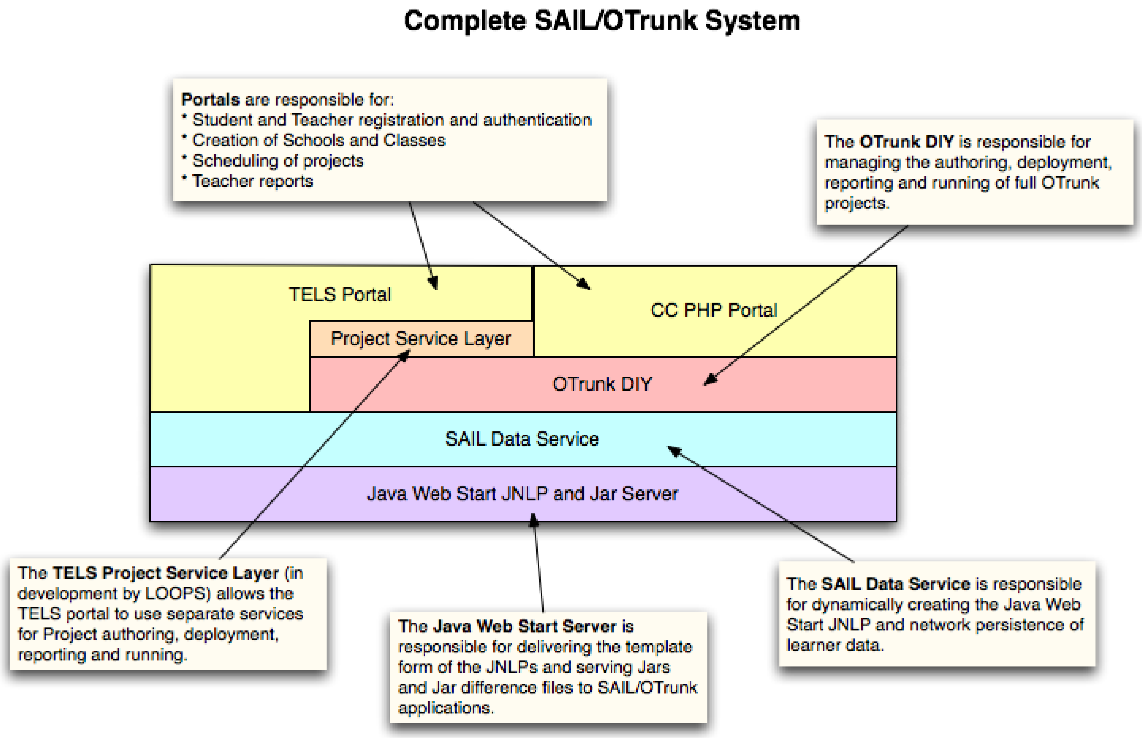
There is an SAIL Community online timeline[4] starting in February 1999 with a WISE Retreat and the start of the TEEMSS project at Concord Consortium that describes contributing projects, meetings and milestones in the SAIL/OTrunk community.

3 https://confluence.concord.org/download/attachments/16603/SAIL.overview.pdf

4 http://www.xtimeline.com/timeline/SAIL-Community

SAIL/OTrunk Architectures

The following diagram shows the relationships between the different layers of the SAIL/OTrunk framework.



At the top layer are Portals. Portals are responsible for Teacher, Student, and Administrator user registration and authentication. In addition Portals allow the creation of Schools and Classes and the scheduling of available projects for activities. Portals also support resources that support Teacher review of student work and grading.

There are two existing **Portal** implementations that work with the SAIL/OTrunk framework.

The **CC PHP Portal** was first deployed in May 2007 for Concord Consortium's ITSI project. This is a relatively simple Portal developed that was developed in just a couple of months in PHP to work with the existing OTrunk DIY system. As of August 2008 approximately 32,000 learner sessions had been initiated through the CC Portal for five different projects at Concord Consortium.

The **TELS Portal** is written in Java and has been under continuous development since Summer 2006. As of August 2008 approximately 12,000 learner sessions have been initiated through the TELS Portal. The TELS Portal supports reporting of student work done in WISE3 notes as well as indications of student progress through a WISE3 project. Teachers also can grade student work and the results and comments can be delivered to the learners the next time they run the WISE3 project. Up until September 2008 the TELS Portal only had the capability to run WISE3 projects. In October 2008 at the Ontario SAIL retreat Scott Cytacki (CC) and Hiroki Terashima (UC Berkeley) were able to get the initial implementation of the TELS Project Service Layer working and run a full OTrunk project from the OTrunk DIY that started and persisted learner data.

The **TELS Project Service Layer** (PSL) is an external project service abstraction in the TELS Portal which enables the layering of the higher level TELS Portal functions with multiple project implementations. Initially the PSL is being designed to allow the TELS Portal to work with the OTrunk DIY so that:

Students can run LOOPS activities deployed in the DIY.

Teachers can view LOOPS reports generated by the DIY

Teachers can modify LOOPS activities or activity sequencing per student, workgroup or class through a LOOPS report managed by the DIY

There are two types of activities being developed for LOOPS. Ones for the Incremental LOOPS Study using existing TELS WISE3 projects, and the Quantum LOOPS activities that pilot a more flexible curricular structure and the greatly enhanced reporting capabilities in a full OTrunk implementation. Both of these activity types will be able to be run from the TELS Portal. The Quantum LOOPS activities will be implemented in the OTrunk DIY and work with the TELS Portal through the TELS Project Service Layer. It is likely the Incremental LOOPS activities be run this way also.

The **OTrunk DIY**[5], programmed in Ruby on Rails was first developed for the TEEMS NSTA workshop in April 2006. The first version of the DIY allowed teachers at the NSTA workshop to use a simple web template to author TEEMSS2-style OTrunk activities and later use these with their students. In November 2006 the TEEMSS2 OTrunk DIY was integrated with SAIL persistence and the first SAIL/OTrunk system that allowed teachers to create and modify SAIL/OTrunk activities went online.

The OTrunk DIY has very simple Portal characteristics, Users can register and become Activity Authors. When any registered User runs an Activity they become a Learner for that Activity and simple reports are available for all the Learners for that Activity. The OTrunk DIY does not currently include support for the higher level abstractions of Teachers, Students, Schools, and Classes – just Users, Author, and Learners.

Even though the Portal characteristics of the OTrunk DIY are simple the Ruby on Rails web framework has proven to be an extremely productive technology for developing new types of activities and reporting systems. The agility made possible by the Ruby on Rails framework was very well suited to the development of the web integration layer of the initial LOOPS Reporting system (described later).

In addition the use of Ruby is now being directly integrated into the SAIL/OTrunk system with a first-class implementation of Ruby in Java called Jruby. In the last 18 months Sun has supported development of a high-performance implementation of Ruby running in the Java Virtual Machine called Ruby. Concord Consortium expects that the further integration of JRuby, a flexible object-oriented scripting language with the SAIL OTrunks framework will provide great research benefits.

The first place this integration of Jruby scripting and SAIL/OTrunk has shown great value is in

5 https://confluence.concord.org/display/CSP/DIY

the architecture of the LOOPS reporting system.

The reports for LOOPS are built as OTrunk activities themselves which gives the reports full access to all the learner data as well as the complete Java objects implementing the models, graphs, drawings used by the learners. While some of the results of learner work can be presented easily on the web many other aspects of learner work can only be practically presented by representing the data using the rich Java objects.

The second place that JRuby has been used in LOOPS is in development of the SmartProbe script capability in collaboration with CC's UDL project. The SmartProbe JRuby script libraries allow an activity author to easily extend the forms of responses to a question to include artifacts in a graph itself – for example an answer can now be a user-entered Data Point Label identifying for example the maximum or minimum value in a specific dataset.

The **SAIL Data Service**[6] (SDS) is the web service that supports dynamic creation of Java Web Start jnlps for launching SAIL/OTrunk learner and report instances. In addition the SDS manages learner data persistence. This web application is also written in Ruby on Rails.

The **Java Web Start JNLP and Jar Server**[7] is a Java web application responsible for delivering the template jnlps and versioned Java jar code archives used by all SAIL/OTrunk instances. When bugs are found or new features need to be deployed another version of the jars and jnlps are deployed and the next time a user runs the SAIL/OTrunk instance the jar files in their local cache that are out of data are updated automatically. This server has the ability to determine whether supplying just the difference between cached jar and the newer version will be smaller than supplying the entire new jar and selecting the appropriate response.

6 http://www.telscenter.org/confluence/display/SAIL/SAIL+Data+Services

7 https://confluence.concord.org/display/CCTR/Setup+Local+Jnlp+Server

LOOPS CONTRIBUTIONS TO THE SAIL/OTRUNK FRAMEWORK

Initial installation and running SAIL/OTrunk activities in a school setting

Running SAIL/OTrunk activities in a school classroom can generate large loads on the schools connection to the Internet. The activities and reports being developed for LOOPS make even more extensive use of the new capabilities of these frameworks and at this point add to this problem.

Depending on how many OTrunk, modeling, probeware, collaboration, and inquiry components are delivered to a classroom the initial download of the Java Web Start application code can range from 12 to 60MB.

When a school connection to the Internet is just a single T1 link (nominally 150,000 bytes per second) and a classroom of 20 computers starts a SAIL/OTrunk activity for the first time we have found that getting the Java Web Start application loaded onto each computer for the entire set of class computers can take from 20 minutes to over two hours. Here's the worst-case calculations:

Java Web Start compressed code resources:	60	MB
Computers starting the first time:	20	
Speed of Internet Connection	150	kBps
Time to download all the resources:	133.33	minutes

These Java resources are normally stored in a cache directory in a users home folder. Once the initial download has occurred subsequent downloads of Java application code only occur when a bug is fixed or a new feature is added. The web service responsible for delivering the Java web start code resources includes the capability of delivering just the difference between the earlier version and a newer version of a Java jar code resource. The result is that subsequent startup times of the application can often be just a few minutes on a school with a slow connection to the Internet.

Small USB School Server

In March 2008 in collaboration with the UDL project at CC we developed a deployable SAIL/OTrunk small school server that contains all the services and resources necessary to run a LOOPS project in a school or classroom. The small server is a Linux system on a USB hard drive that can be booted on many standard Windows PCs. The services and resources deployed to the server consist of:

Activity resources: otml, images, flash, movies

Tomcat Java Web Start Jnlp and Jar server

Sail Data Service

Project-specific Do-It-Yourself Otrunk authoring and deployment system

CC's PHP-Teacher Portal

The server itself is delivered on a USB hard drive. This hard drive can be connected to almost any modern Windows PC and when booted will start up a Linux system that contains all the resources and starts all the services necessary to run a SAIL/OTrunk project.

This solution was delivered to a school in in Fresno California participating in the UDL project in April 2008 and tested for several months. This school has only a 768kbps connection to he Internet and the deployment of the Small Server to this school made running SAIL/OTrunk projects possible.

Local Java Web Start Proxy

We developed an adaptation of the standard Java Web Start delivery of Java code resources[8] (jars) in which a student or teacher computer that had already downloaded the Java application could act as a local proxy for the jars that make up the application for other computers on that local subnet. Typically the computers in a classroom are all on one local high-speed subnet. After one computer starts up the Java application it advertises it's availability as a SAIL/OTrunk jar proxy server server on the local subnet using the open source JmDNS[9]Java implementation of the multi-cast DNS protocol ZeroConf. This is a Java implementation of the same services Apple calls Rendezvous. Scott Cytacki contributed bug fixes and a re-working of the threading model used in this existing open source project.

While we believe this approach has promise initial tests have not show as much speed improvement as we would like.

Initial preloading of Java resources from a CDROM or USB flash drive

We also developed a downloadable MacOS disk image file that when expanded made available an executable application that when run would pre-load a students Java web start cache with the Java jar resource for the SAIL/OTrunk application. This application when copied to a CDROM or USB flash memory drive could then be used to populate the Java web start cache in a students home folder with the Java jar resources. An important detail in both this solution and the Local Java Web Start Proxy is that the resources stored in a student's local Java web start cache need to appear to be from the original server at Concord to the Java Web Start application that starts up the SAIL/OTrunk application.

While this worked reasonably in some school environments in a situation where a school has implemented student home folders on a network file server and a network login for the student on any student computer in the school this again caused slower performance than we would like. The problem here is that once a student has run the SAIL/OTrunk application once the cache of the Java jar resources only temporarily stored on the hard-drive of that specific computer. When the student moves to another computer the next day the resources in that student's networked home folder now need to be copied to a temporary location on the new computer.

8 http://www.telscenter.org/confluence/display/SAIL/Local+Webstart+Proxy

9 http://jmdns.sourceforge.net/

We developed a new variation of the preload strategy in which the jar resources were copied into a location which can be shared among all users of a computer. The result of this is that once the SAIL/OTrunk resources have been pre-loaded on a specific computer these resources will be used when any student in the school runs a SAIL/OTrunk activity.

So far the pre-load solution has only been developed for MacOS X.

Delivery of Java resources using the git distributed code management tool.

We have done some promising experimentation into using the distributed source code management tool called git[10] for as an alternative to Java Web Start for deploying updated code for SAIL/OTrunk instances. **Git[11]** is an extremely fast distriibuted source code management application however it can also be used as a a system for managing all kinds of versioned content. Git is optimized for managing thousands of smaller files and the changes associated with small sets of these files during the revisions of source code as software is developed. Deploying a SAIL/OTrunk instance with every possible feature enabled with Java Web Start will involve a collection of over 200 versioned jar files that add up to over 100MB (see the loops-pas-otrunk-authoring[12] for an example). Git manages some of it's incredible efficiency by quickly generating differences of compressed objects stored in a repository. However git algorithms are not efficient when calculating the differences between one large opaque binary jar file and another. Git however can be quite effective if the Java code resources are instead stored and saved as the many thousands of individual Java binary class files that constitute the jars. In initial experiments once a local git clone of the Java code has been made the amount of data transferred over the network when a bug is fixed or a new feature is added can be much smaller. In one test the amount of data sent by Java Web Start as a jar difference was 24k. The equivalent operation using git transferred just 400 bytes – **a factor of 50 smaller!** Several projects at CC are contributing towards this effort. This means that the updating step in the SAIL/OTrunk startup process which can take several minutes may in the future only take a few seconds. This would make wide-scale deployment much more practical.

10 https://confluence.concord.org/display/CCTR/Storing+Java+jars+and+classes+in+git

11 http://git-scm.org/

12 http://jnlp.concord.org/dev/org/concord/maven-jnlp/loops-pas-otrunk-authoring/

Curriculum Tools

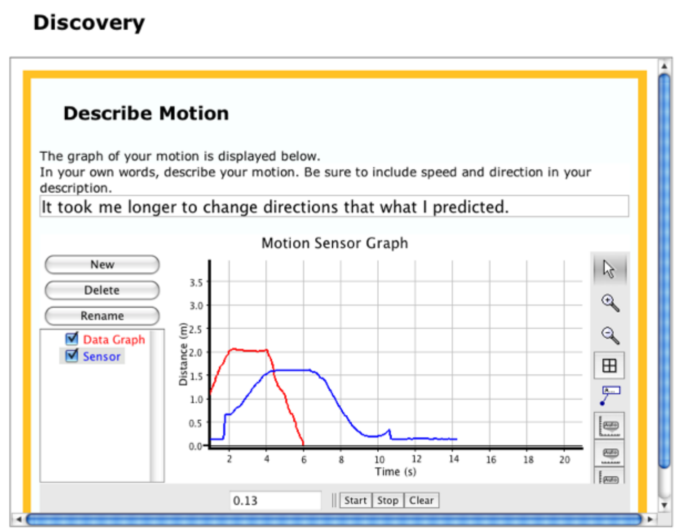
The LOOPS project has been working with other projects at CC to further develop Smart Graphs, Models, and Tables.

A demonstration of a simple LOOPS activity and report took place at the TELS Retreat in August 2008 in Berkeley CA. The activity covered one aspect of one-dimensional motion and was designed to prototype new forms of activity and reporting.

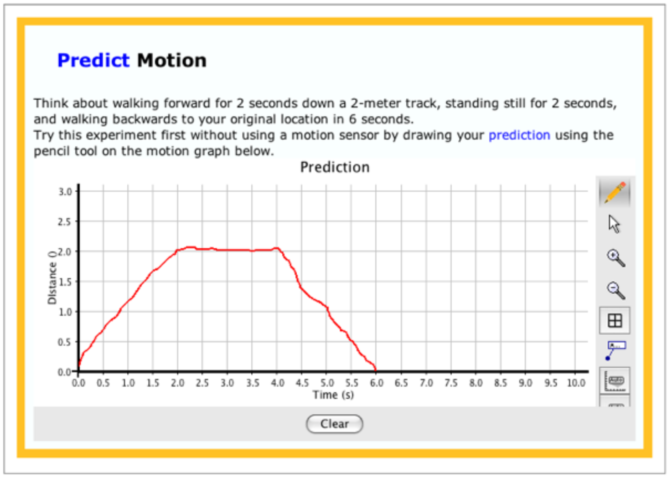
The one-dimensional motion activity had Discovery and Challenge sections.

The Discover section has a simple pedagogical pattern consisting of a prediction followed by a data collection with a sonar-ranger probe for measuring distance followed by a reflection.

Here are the three pages:

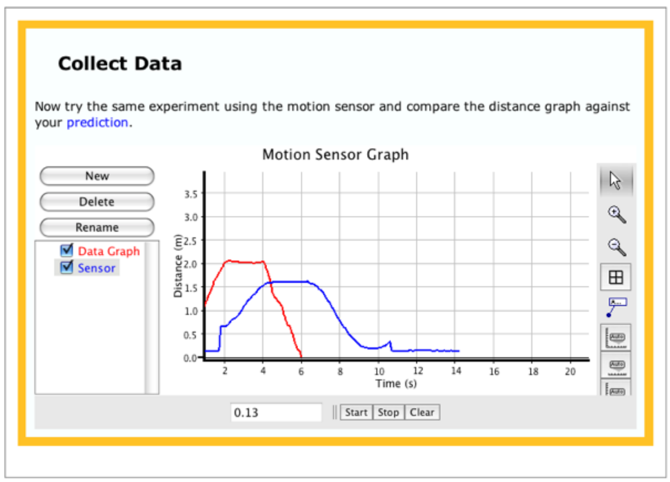


Discovery

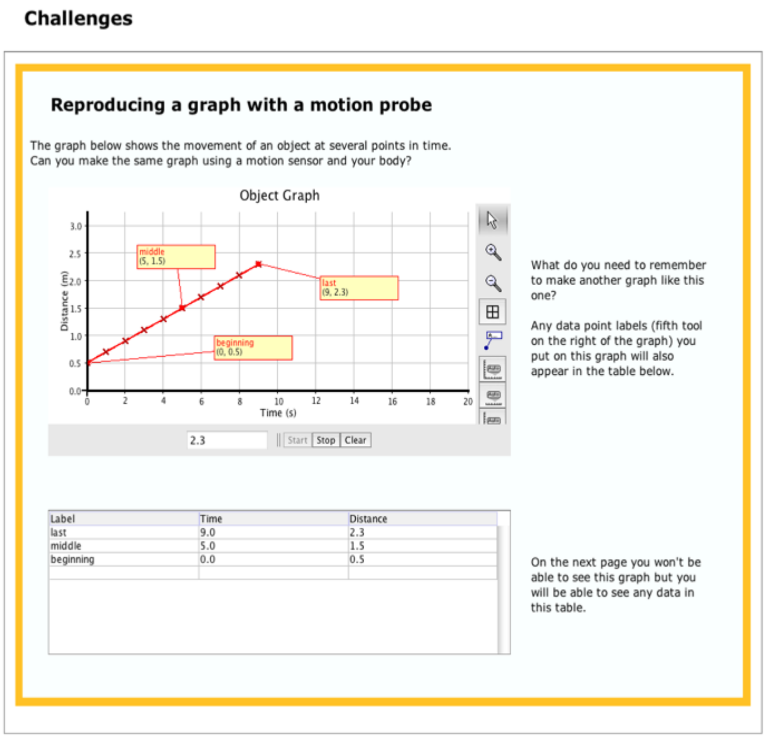


The Challenge section was similar but harder. When the students were asked to duplicate the initial graph on the second page they were not able to see the original graph. Instead they were encouraged to use the OTrunk Graph's Data Point Label tool to make notes about the original graph and use these notes to scaffold their production of a similar graph using the motion probe.

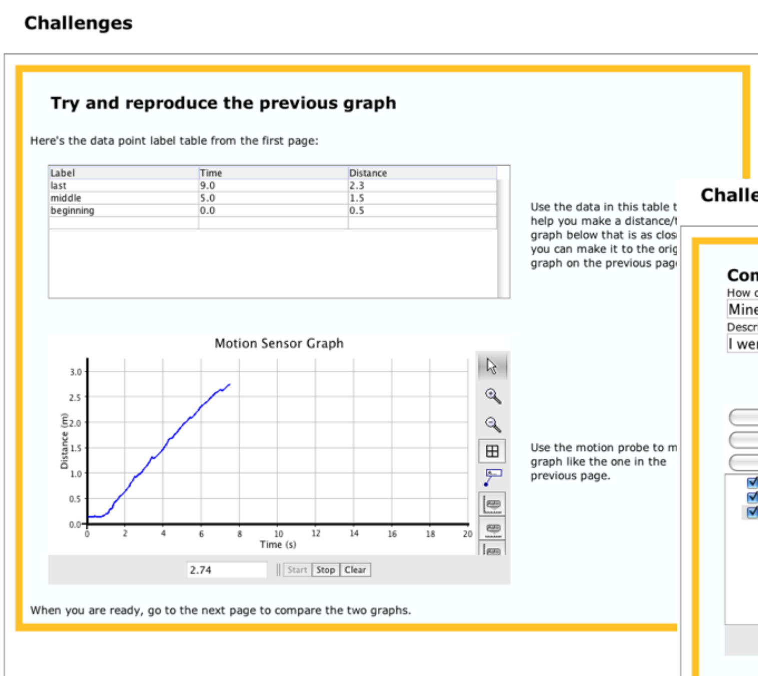
Discovery



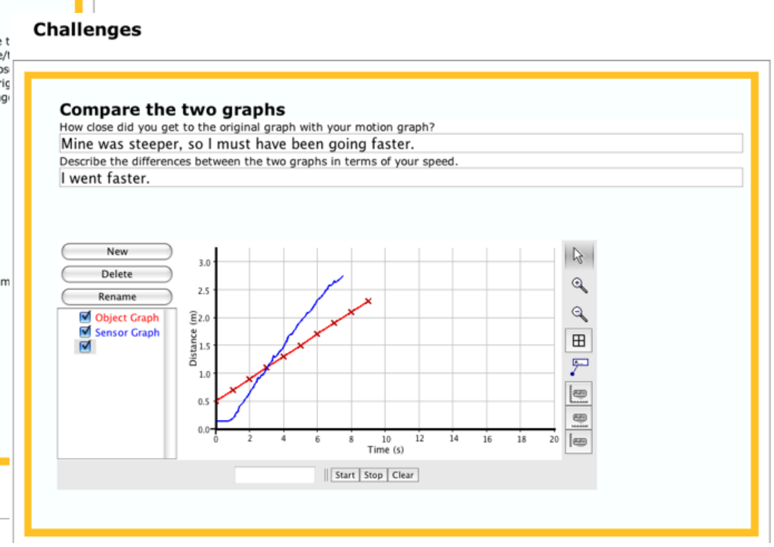
Here's a screen shot of the first page in the challenge:



Here's the second page:



And the third page:



Authoring

Goal: to enable curriculum developers who are not programmers to author LOOPS activities.

Most of the existing LOOPS WYSIWYG authoring system is based on work done by Concord Consortium's UDL project however the LOOPS project has contributed new Smart Graph capabilities which allow learner manipulation and interaction with a graph to be used as a response to a question or challenge.

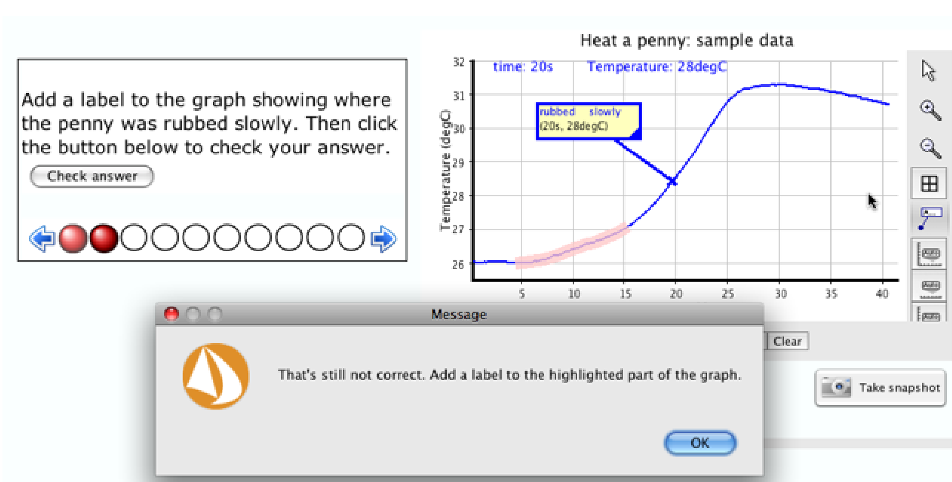
The initial form of response types for a Smart Graph question include:

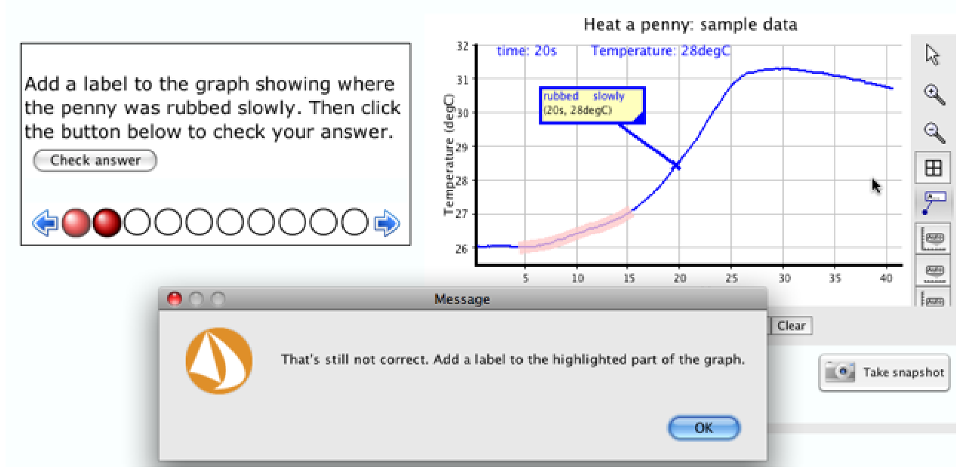
Entering a data point label

Entering a numeric value

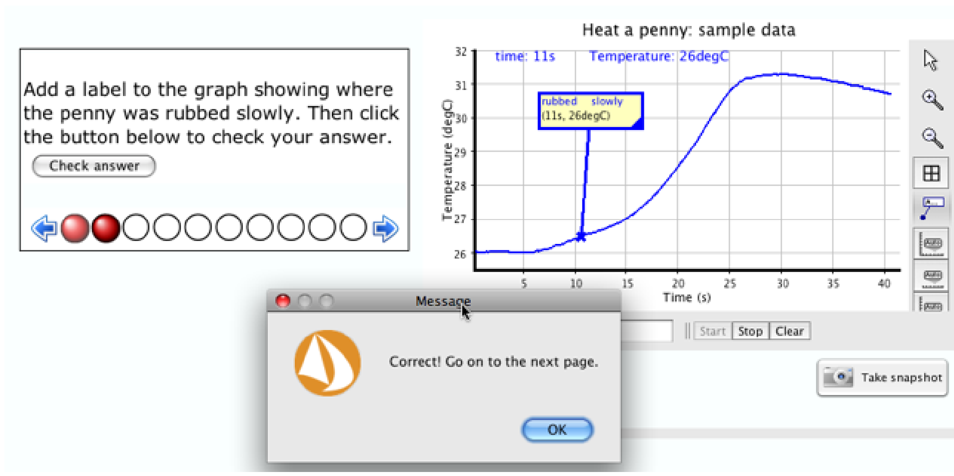
Here's an example of the use of a Smart Graph Question from the UDL project. In this example a series of questions are asked about a graph of data showing the warming of a penny that has been heated by rubbing.

In the question below the learner is asked to place a label in the section of the graph where the penny was rubbed slowly. The placement of the data point label is incorrect and when the student checked her answer the activity displayed a scaffold consisting of text and a highlighting of correct region of the graph. The author of this activity specified the correct region of the data, wrote the text in the dialog and chose whether the graph region should be highlighted. In the example below the highlighted region did not appear until the learner had placed a data point label in two successive incorrect locations and checked their answer.





After moving the data point label to a new location and checking her answer the learner finds out that this is indeed the correct location.



After embedding a Smart Graph Question into the activity the author defines the interaction by editing a short Ruby script. The script below defines how the activity will respond to the question illustrated above.

```
response_key = {
  :response_type => :label,
  :correct_range => { :range => 5..15, :axis => :x },
  :no_answer_entered =>
    { :text => "Use the label tool to add a label to the graph.", :highlight_region => false  },
  :correct =>
    { :text => "Correct! Go on to the next page.", :highlight_region => false },
  :first_wrong_answer =>
    { :text => "That's not correct. Look for the part of the graph where the temperature increases slowly. ",
:highlight_region => false  },
  :second_wrong_answer =>
    { :text => "That's still not correct. Add a label to the highlighted part of the graph.", :highlight_region => true },
  :multiple_wrong_answers =>
    { :text => "That's still not correct. The penny was rubbed slowly between 5 and 15 seconds. ",
      :highlight_region => true }
}
```

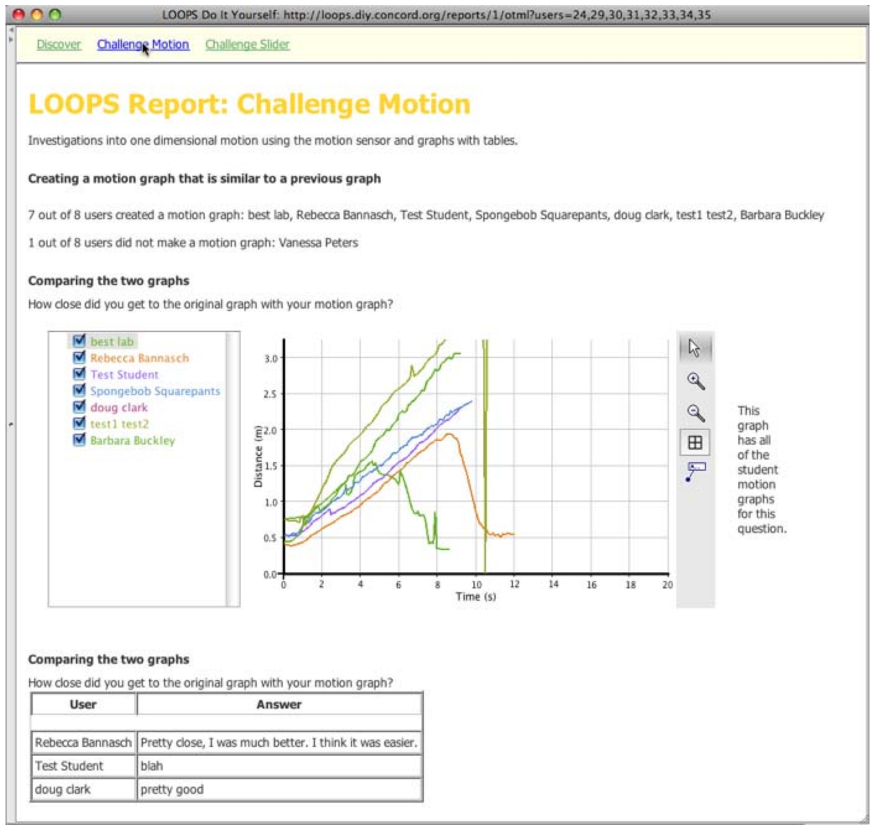
Reporting

Describe and give examples of LOOPS reports, emphasizing their advantages over previous versions, including tracking teacher-initiated changes, real-time reporting of student work, grouping of students, and support for performance assessment rubrics.

A great deal of work has been done to implement reporting on the full suite of rich OTrunk objects which learners can interact with and from which learner data are saved.

OTrunk reports can be generated for any of the learners who ran the LOOPS activity at the TELS Retreat. This example shows how the report section describing the Challenge Motion section includes the OTrunk graph and reflection questions showing all the learners data.

In addition statistics can be calculated and displayed.



The LOOPS project has added a new Ruby-based architecture to SAIL/OTrunk to enable a much more agile and flexible development of reports. Before these LOOPS additions the mechanisms for determining the layout of a report were all hard-coded in Java.

For example the display of the first two sections on the report page shown above were created by this Jruby ERB template:

This style of rendering an html template with references to specific objects is familiar to

```
<h3>Predicting Motion</h3>

<% users_who_made_prediction_graph =  users.find_all {|user| hasUserModified $predictionData, user } %>
<% users_who_did_not_make_prediction_graph =  users.find_all {|user| ! hasUserModified $predictionData, user } %>


<p>
  <%= users_who_made_prediction_graph.length %> out of <%= users.length %> users created a prediction graph: 
  <%= users_who_made_prediction_graph.collect { |user| user.name }.join(', ') %>
</p>
<p> 
  <%= users_who_did_not_make_prediction_graph.length %> out of <%= users.length %> users did not make a prediction graph: 
  <%= users_who_did_not_make_prediction_graph.collect { |user| user.name }.join(', ') %>
</p>

<table border="0" width="900" cellspacing="20">
  <tr>
    <td width="800">
      <%= embedObject multiUserGraph($predictionGraph, $predictionData) %>
    </td>
    <td>
      This graph has all of the student predictions for this question.
    </td>
  </tr>
</table>
```

almost any web application programmer. This means that the task of creating and modifying reports can now be done by a much larger pool of programmers than just programmers who know Java Swing development.

Even working with native OTrunk objects themselves is much easier and more agile in Jruby than in Java. For example here is the section of JRuby code which dynamically creates the Data Graph with data from all the learners in the example above:

LOOPS Teacher Dashboard and Information Management

```
def colors
  ["65AE24", "E08024", "905BF5", "568AD8", "B03A7F", "99A62A"]
end

def nextColor
  color = colors[@colorIndex % colors.length].hex
  @colorIndex += 1
  color
end

def multiUserGraph(dataGraph, dataStore)
  otCreate(OTDataGraph) { |multiUserGraph|
    multiUserGraph.title = dataGraph.title
    multiUserGraph.showGraphableList=true
    multiUserGraph.graphableListEditable=false
    multiUserGraph.xDataAxis = dataGraph.xDataAxis
    multiUserGraph.yDataAxis = dataGraph.yDataAxis
    @colorIndex = 0
    graphables = multiUserGraph.graphables
    users.each { |user|
      next unless hasUserModified(dataStore,user)
      graphables.add(otCreate(OTDataGraphable) { | graphable |
        graphable.name = user.name
        graphable.color = nextColor
        graphable.xColumn=0
        graphable.yColumn=1
        graphable.locked=true
        graphable.drawMarks=false
        graphable.dataStore = userObject(dataStore,user)
      })
    }
  }
end
```

We have recently added the capability for teachers to modify the form or sequencing an activity takes for a learner, workgroup, or the whole class while viewing a SAIL/OTrunk report. A teacher can view a report that contains rich objects representing the results of student investigations with graphs and models and make decisions about what steps might be taken next in this context. This is made possible at a lower level by the new Teacher Overlay services provided by SAIL/OTrunk, OTrunk web dav services and the OTrunk DIY web application. This new Dashboard capability is integrated with the TELS Portal through the new Project Service Layer described below.

LOOPS Portal: Adding a Project Service Layer to the TELS Portal

As described earlier programmers at CC have worked with programmers at Berkeley to add the ability for the TELS Portal to work with many different types of projects through a Project Service Layer. The initial use of this is to allow use of the TELS Portal for managing Teachers, students and classes while also supporting new forms of projects and reporting LOOPS which extend far beyond what the existing Wise system provides   curriculum development tools and the LOOPS Teacher Dashboard and Information Management.

A central feature of LOOPS is the persistence of student data and the use of such data by the classroom teacher. Describe the technologies we are creating so that data generated as students use our technology can be used creatively by teachers both during and after class. Describe the new features of the LOOPS Teacher Dashboard (e.g., managing groups of students) that the SAIL portal doesn't have, thus justifying our development of a second portal. Provide brief description of the process of portal development in JRuby and the advantages of JRuby over Java for that purpose.

UNIVERSITY OF CALIFORNIA, BERKELEY ACTIVITIES

The UC Berkeley sub award for the LOOPS project was executed in 2008. Leadership includes Marcia Linn (Director) and Kathy Benemann (Manager), Doug Kirkpatrick (Program Coordinator). Graduate students include Kevin McElhaney, Helen Zhang, Phil Daubenmeir, and Jenny Chiu. Technology staff includes Hiroki Terashima, Geeff Kwan, and Tony Perritano. Staff includes David Crowell and Jon Breitbart. The Berkeley Institutional Review Board has accepted UC Berkeley's LOOPS protocol.

UC Berkeley participants have contributed to a face-to-face meeting in Concord and regular technology and leaders meetings (averaging three times a month). In addition, Bell and Benemann have coordinated on a weekly basis. In addition, we have contributed to the WIKI for LOOPS.

During the first year we have reviewed and pilot tested possible items for baseline assessments, recruited teachers and schools, began the process of defining LOOPS scenarios, and conducted meetings with potential LOOPS users. In addition, we have reviewed possible curriculum and technology designs and considered ways to incorporate LOOPS.

ASSESSMENT

Baseline assessments for Force and Motion and Chemical Reactions items were administered to both TELS and non-TELS students based on convenience. The two groups are not comparable as they come from schools with different Academic Performance Index scores. These are all items that have been released by TIMSS or other testing programs.

The pilot tests can be used to establish goals for the new curriculum materials. As the bar chart below shows, performance on Force and Motion items suggests a need for intervention in student learning in this topic area (Figure 1). For schools that did not study TELS, this can be seen as a baseline. As is apparent, students have limited understanding of the topics in these assessments.

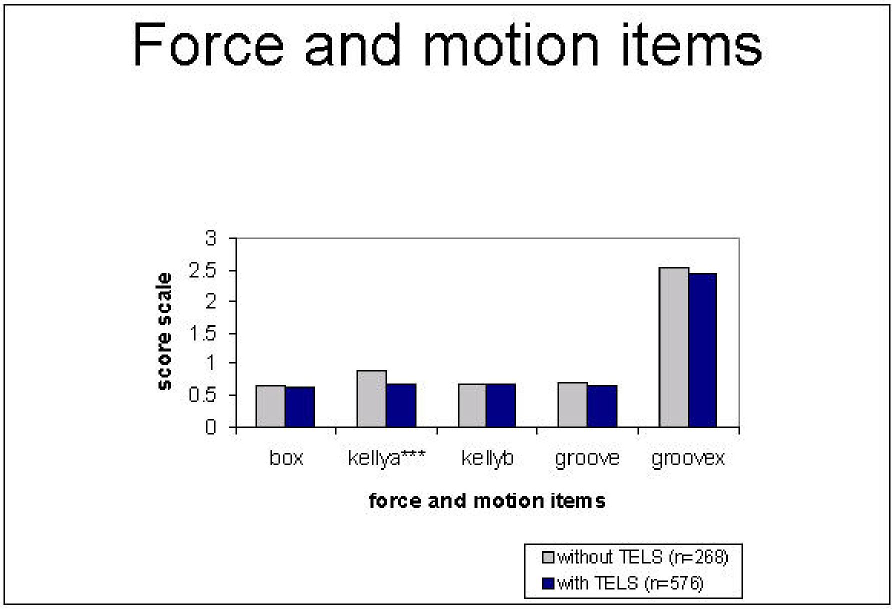


Figure One: Five items administered to students in TELS schools who either did or did not study any TELS units the previous year.

The Chemical Reactions items were administered to students in similar schools. An analysis of Chemical Reactions items indicates significant advantage to students who experienced TELS instruction consistent with the impact of the unit in the past (Figure 2).

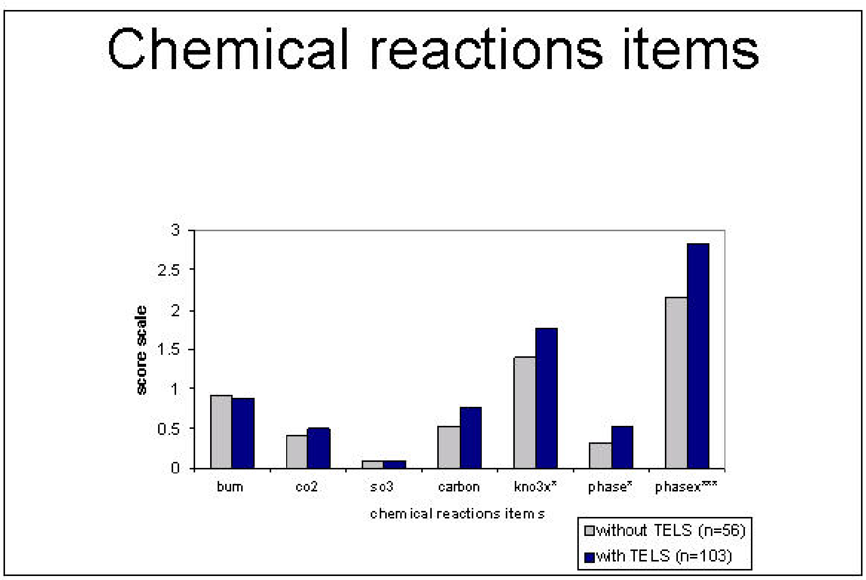


Figure Two: Seven items administered to students of two TELS teachers.

LOOPS Schools

UC Berkeley has recruited three schools to participate in the LOOPS project and one school to participate as a potential back-up school. All of these schools have participated in past TELS-related research programs and have garnered administrative and district-level support for integrating effective use of technology into science curriculum. Several formal and informal meetings have been organized since June 2008, during which we collaborated with teachers and researchers in the curriculum and technology design process.

We secured pacing guides for physical science courses. We have reviewed these guides as well as the California standards. Since this is the first year of use of the guides we envision some revision after the plan is tried out. The timing of the units and the time devoted to topics appears a bit disjointed. To make LOOPS successful we will need to align the guides with our curriculum design plan.

Our first formal meeting in July provided us with invaluable insight into teacher's successes and challenges when teaching Force and Motion topics to middle school students. Most of the teachers expressed excitement about their prior use of motion probes and indicated interest in continuing to use this technology. The teachers were somewhat confused about the goals of LOOPS and how the program would be enacted in their classrooms. In response we began the process of creating scenarios.

During our second formal meeting in August, attended also by Concord Consortium project manager Ken Bell, we were able to gather teacher perspectives into revising current TELS modules to fit LOOPS research and instructional goals, while also evaluating new technology tools. Kevin McElhaney, who has been serving as the LOOPS graduate student researcher, played an essential role during these planning meetings, providing both teachers and senior researchers avenues for designing activities and the accompanying technology components.

These meetings underscored the importance of clarifying LOOPS scenarios and developing proof of concept technologies. These materials will be discussed with teachers as they become available.

LOOPS Scenarios

We have participated in the iterative process of drafting LOOPS scenarios. These discussions are helping us identify the kinds of feedback systems that might be desirable in the classroom setting. UC Berkeley, Concord Consortium, and Toronto have revised these scenarios. We will soon discuss these ideas with teachers and further refine the scenarios.

We have discussed various curriculum approaches, recently meeting with Tinker at Berkeley to refine the context of instruction and consider appropriate pacing arrangements.

UNIVERSITY OF TORONTO ACTIVITIES

Continued development of the Scalable Architecture for Interactive Learning (SAIL).

Since 2003, Professor Slotta has led an international team of researchers and technology designers in developing SAIL, which is a java-based framework for the development of interactive, interoperable learning materials and environments. SAIL has been the basis of our development activity in the NSF-funded TELS center, and is one of the primary deliverables of that effort. It has served as the basis of all technology development in subsequent projects, including LOOPS

Organized a SAIL technology architecture workshop. June 23, 2008. Utrecht, The Netherlands

Professor Slotta organized, with collaborator Turadg Aleahmad and Stephen Bannasch, a pre-conference workshop where members of the international community were exposed to the core LOOPS technologies and encouraged to design new applications that would connect to their own research. 15 participants gathered in Utrecht, the Netherlands, including representatives from a large European Union Framework 7 project called SCY that is interested in collaborating in technology development, as well as members of prestigious U.S. and Scandinavian labs. This workshop was a full day event, with participants first exploring SAIL and LOOPS technologies, then breaking into focus groups (one on technology architectures and repositories, and another on curriculum and assessments).

Convened a SAIL repository development workshop. August 1-5, 2008. Berkeley, California.

Building on the earlier technology workshop, Professor Slotta invited the two lead technology developers from the SCY (Science Created by You) project to participate in a hands-on development workshop held in Berkeley, California. SCY is a large collaboration project funded by the European Union's Framework 7 program (8.5 Million Euros from 2008-2013). Professor Slotta is a partner in this project, as he is eligible being from a Canadian institution. Slotta is a primary member of the SCY technology architecture and pedagogical agents work packages. To ensure that SAIL is of direct relevance to SCY, Slotta convened a workshop where the two lead programmers from SCY joined the three lead programmers from the TELS center and two programmers from his group at University of Toronto, to develop a new Repository Of Open source Learning Objects (ROOLO) that would interconnect with the existing SAIL portal that all three groups were using. This repository was successfully developed and is now being used in all three locations, with Slotta's team in Toronto taking a lead role.

LOOPS technology development meeting. August 5-8, 2008. Berkeley, California

In conjunction with the fifth (and final) annual TELS retreat, Slotta led a break-out session of the various members of the TELS and LOOPS technology teams to discuss issues and agendas for technology development (for which Slotta has overall responsibility). Several major topics were discussed, including authoring, reporting, portals, and repositories. A SAIL technology retreat was planned where these topics would be more fully discussed, to be held in mid October, in Ontario, Canada.

ONGOING LEADERSHIP AND RESEARCH MEETINGS.

Professor Slotta has joined regular meetings of the LOOPS leaders where research and technology development is planned. He also convened a weekly technology development meeting, where other members of his technology group participated. Finally, Slotta and two PhD students, Cheryl Madeira and Naxin Zhao, attended bi-monthly meetings of the LOOPS research community.

External Evaluation Report

Logging Opportunities in Online Programs for Science (LOOPS)

Dr. Barbara C. Buckley

September 30, 2008

The goals of the external evaluator, Dr. Barbara C. Buckley, in reviewing the National Science Foundation-funded LOOPS project are to evaluate project execution and fidelity to plan by providing constructive observations on project activities and findings and recommendations for future efforts.

The external evaluation efforts of this year focused on understanding project goals, progress being made toward project objectives, and the roles of the various institutions and personnel.

This report is based on data collected during the following evaluation activities:

1. Review of Proposal
2. Review of NSF Questions and LOOPS Answers
3. Attendance at TELS retreat August 6, 2008)
4. Interviews and discussions with project personnel (August 6, 208)
5. Extensive discussions with Concord personnel (September 17-18, 2008)
6. Review of project Wiki (http://confluence.concord.org/display/LOOPS/Home)
7. Review of Web site and Portal (http://loops.concord.org/)
8. Review of annual report to NSF

Project Goals

LOOPS will [provide] teachers with timely formative feedback that provides insights into student learning and gives teachers instructional options that are data-driven.

Part of a long-term collaboration among the Concord Consortium, the University of California, Berkeley, the University of Toronto, and North Carolina Central University, LOOPS will create timely, valid, and actionable reports to teachers by analyzing assessments and logs of student actions generated while students use online curriculum materials. Drawing on these reports, teachers will then be able to make data-based decisions about how to best help their students learn.

LOOPS will study the effect of putting teachers in a feedback loop of data on both student and teacher learning. These feedback loops will be classroom-tested with inquiry-based materials using probes and models focused on eighth grade physical science.

In order to provide feedback to teachers, LOOPS curriculum activities will collect data on student progress—what activity each student is working on or has completed, student responses to questions, student actions as they conduct inquiry using models and probes, plus scores on various explicit assessments. LOOPS activities will calculate a few key indicators of inquiry skills in real time and present them in a format that teachers can use.

Progress toward Project Goals and Objectives

The following sections describe LOOPS project objectives and progress made toward those objectives targeted during Stage 1.

PROJECT OBJECTIVES

The following sections describe progress made toward these objectives as relevant to Stage 1 activities.

Develop LOOPS technology

Significant effort has been expended on developing the infrastructure for logging student actions, analyzing their actions in real-time (based on prior work by the Modeling Across the Curriculum project (Buckley, Gobert, Horwitz, & O'Dwyer, 2008) and the TELS project (McElhaney, 2006)), and delivering reports to teachers in class as well as after class, along with other supportive resources. The major obstacle to this effort at this point in time is an incompatibility between the existing grading tool used in the TELS project via the WISE 3.0 portal and the otml reports that display teacher reports. This will have to be resolved in order to deliver the LOOPS Planning and Classroom Enactment Resources Version 1.0 planned for Stage 1.

Integrate technology with existing materials

The force and motion curriculum drafted by teacher-developer Jeff Schoonover effectively incorporates existing online learning activities developed by previous projects into a coherent curriculum for force and motion with the addition of new activities designed to take advantage of the Smart Graphs. Since these are currently under development, the state of these activities changes from day-today in terms of their functionality for students or teachers. Since most of the curriculum is based on existing activities, LOOPS integration will require not only logging student actions and responses, but also analyzing them in real time and displaying the teacher reports. As noted above, the teacher reports are dependent on the successful resolution of the incompatibility described in the previous paragraph.

Study inquiry learning

Baseline assessments of content knowledge for force and motion and chemical reactions have been administered to nearly a thousand students. The results will inform design of the curriculum, which is currently underway.

Develop professional development strategies

Prior work by these collaborators both collectively and individually has included not only professional development but also a long history of involving teachers as developers and design partners. For this project the focus will be on how to interpret and effectively use the data provided by the teacher reports. In this first year teacher professional development strategies will emerge from the interactions during working sessions with the teacher developers.

Disseminate the materials and approach

Project materials and deliberations are already available on the project website & wiki (http://loops.concord.org/ and http://confluence.concord.org/display/LOOPS/Home. In addition, the workshops convened by Jim Slotta, University of Toronto, are a very productive and concrete mechanism for disseminating open source software tools as well as fostering their development.

Institutional Roles

During the first year of the project there has been considerable negotiation focusing on the respective roles of the institutions involved and recruiting the personnel to carry out the work, as would be expected. I am not totally sure that these negotiations have been concluded, but given the long history of the collaboration, I am confident that they will be.

My understanding is that Concord Consortium leads the technology development and integration efforts. Marcia Linn's team at the University of California, Berkeley leads the research effort. Jim Slotta's team at the University of Toronto focuses on the technology required to enhance community support for teachers. North Carolina Central University will be involved in both teacher development and research.

Conclusions

Overall, the LOOPS project is making good progress toward achieving their goals and objectives for Stage I in preparation for taking these materials into classrooms in Stage II. They have:

- Piloted student content knowledge assessments that will enable them to determine impact of their intervention.
- Used the results of the baseline assessments to tailor selection and development of the curricular activities targeting relevant concepts.
- Drafted the Force and Motion curriculum activities to be piloted in March.
- Drafted the initial specifications and partially implemented the dashboard and reporting tools for teachers.
- Developed the technological infrastructure that will enable the data capture and analysis that is essential for implementing feedback LOOPS for classrooms.

The process of accomplishing these tasks has been highly collaborative and very sensitive to the needs and wants of teachers. The inclusion of teachers simultaneously promotes teacher professional development so that they better understand the affordances of LOOPS reports and supporting materials. This in turn enables the LOOPS project to educate other teachers in the use of these powerful new tools for enhancing student learning in science classrooms.

I see two challenges that the LOOPS project needs to address in order to go forward. The first is the integration of the SAIL, O-trunk and WISE platforms, which needs to be resolved sooner rather than later. I am confident the Concord, Berkeley and Toronto teams will manage to do so in time for the March trials. The second challenge lies in educating teachers about the affordances of LOOPS feedback for enhancing their teaching and the learning of their students. Like any new technology, users need some assistance in seeing not only what the technology can do for them, but also how to use it to transform what they do. The rest of the work involved in this large project is demanding but rests comfortably in the expert hands and minds of the LOOPS teams. I look forward to seeing the results.