The Progress Portfolio:
Designing Reflective Tools for a Classroom Context

Ben Loh, Josh Radinsky, Eric Russell,
Louis M. Gomez, Brian J. Reiser, Daniel C. Edelson
School of Education and Social Policy
Northwestern University
2115 N Campus Drive
Evanston, IL 60208 USA
+1 847 467 2815
{bloh, j-radinsky, eric-r, l-gomez, reiser, d-edelson}@nwu.edu

ABSTRACT
A great deal of effort has gone into developing open-ended inquiry activities for science education as well as complex computer tools for accessing scientific data to help students learn science. To be successful with these tools and activities, students need to learn a set of inquiry skills and to develop a new mode of classroom work: reflective inquiry. In this paper we describe the design of the Progress Portfolio, a software environment to promote reflective inquiry, and we examine the influences of the unique practices and features of classroom contexts on our design process.

Keywords
Children, collaborative learning, education applications, learner-centered design, inquiry support tools

THE NEED FOR REFLECTIVE INQUIRY
There is increasing effort in science education to engage K12 students in more active and authentic learning in which students take responsibility for conducting sustained inquiries [11]. Students are being asked to formulate researchable questions, design their own investigations, gather and interpret data, and communicate their results [7]. To this end, curriculum and technology developers have designed a variety of software tools and learning activities that immerse students in data-rich environments with complex tools to conduct authentic scientific inquiry, such as digital libraries, simulations, and data visualizers. While these complex tools provide new learning opportunities, they also place new demands on students. Students need to learn new skills to manage complex investigations so that they can avoid the potential overload of rich collections of information. They need to coordinate data and interpretations gathered from several environments, such as images from a visualizer and images or text from information resources like the world wide web. When students use tools like the web, they often visit many sites without a clear goal or sense of how these resources are relevant to their investigations [5]. As students explore they lose track of the inquiry, failing to realize possible connections and leaving important questions unresolved. Students are often overwhelmed by the number of analyses they generate, which may be unwieldy to keep in mind or reconstruct. Yet they are unlikely to record data and results whose immediate relevance is not clear. Even when relevant results are recorded, students often do not record how they generated the analyses or what they found important about the results. Students must do more than pursue questions in undirected exploration. Being successful in these new learning contexts requires a new set of skills; students must develop the practices of reflective inquiry. They need to organize, evaluate, and monitor the progress of an investigation. They need to keep inquiry plans and candidate explanations in mind, systematically interpreting their collected data, periodically reflecting, evaluating their progress, and replanning. They must focus their attention not only on the products and results of their work, but also on their inquiry processes. These practices of reflective inquiry can help students to be more successful in their investigations.

Students need to be reflective inquirers not only in order to successfully complete an investigation, but also because they need to learn the process of doing inquiry itself. Students need to learn a style of work and thinking in which they make visible and tangible the reasoning behind their decisions, so that they can evaluate their process with the goal of improving it and learning from it. Students can learn to be better inquirers by reflecting on their mistakes in understanding and dead-ends in their investigative paths. In this sense, the inquiry process itself is a designed artifact, and the need for reflective inquiry is akin to the need for design rationale (cf. [10]). Like designers, students conducting classroom investigations must be able to make explicit their reasoning and tradeoffs, to justify the decisions they have made in the course of their project. Students need to be thinking and talking about the process of their investigation activities, generating a rationale for their inquiry in order to learn from their experiences.

To help students become reflective inquirers with complex tools, we are engaged in design research to develop an inquiry support software environment, and explore its application in a classroom context.

KEY CHALLENGES OF THIS WORK
The two key challenges in this design work are:

1. What kinds of software tools are needed to help students develop reflective inquiry skills?
2. What are the features of the social and activity structures of classrooms that should inform this design?

These challenges form the two foci of our design research, as described below.

Progress Portfolio: A Reflective Inquiry Support Tool
We are designing and implementing a software environment, called the Progress Portfolio, to promote the development of reflective inquiry skills and habits in students. We use the term portfolio to convey the sense in which students use our software to document their work by collecting artifacts representing their investigations. But unlike traditional educational uses of portfolios that only document final products, the Progress Portfolio is meant to document the progress that students are making as they work through their investigations, capturing records of both processes and products.

The Progress Portfolio works in conjunction with a wide range of “off-the-shelf” software-based investigation environments, such as data visualization software, simulations, and digital libraries [9]. These investigation environments provide tools for students to generate and analyze data. The Progress Portfolio augments these investigation environments by providing a workspace in which to document, manage, and communicate about the investigation — a workspace for reflection. It is intended to be used throughout the investigative process, helping learners to document their questions and understandings, their data gathering, analyses, revisions, and presentations. The essential elements of the Progress Portfolio are a set of tools that make the normally invisible aspects of inquiry — i.e. processes, understandings, and reflections — into tangible, concrete objects to be worked with, discussed, presented, and revised, allowing students to tell the story of their investigation and reflect on their inquiry process.

A Classroom-Centered Design Approach
Designing such tools for classrooms poses some unique challenges. Classrooms are environments in which learning necessitates designs that go beyond supporting existing task needs, to foster the learning of new tasks and understandings. Soloway et al. [18] have proposed a Learner-Centered Design approach to developing software environments to address three special needs of users by reconceptualizing them as learners [19]: growth, or the need for change in skills and knowledge; motivation, or the need for support in maintaining focus on work; and diversity, or the need to support a wide range of abilities and styles. This shift in focus from user to learner is consonant with our design considerations for developing reflective inquiry software for classrooms. While it is useful to think of classrooms as being composed of individual user-learners, they are also complex socio-cultural contexts in which teachers and students interact in highly specialized and ever-changing roles and activities [1]. The design of tools for these contexts needs to embody the values of the community in which they are being used [2]. This understanding of context can and should shape software design [20].

Software for schools needs to be informed by a classroom-centered design approach [17]. We see four characteristics of inquiry-oriented classrooms that need special attention:

- **Collaboration is the norm**
  Inquiry-oriented classrooms are collaborative spaces where students work with each other in groups to accomplish complex tasks, reflecting more authentic real world work as well as building group social skills [6; 16].

- **Communication is a primary mode of learning**
  Activity in the classroom is heavily mediated by language. In inquiry-oriented classrooms, student-student communication is a mode of interaction that can encourage the exchange of ideas as well as peer scaffolding. Also, student-teacher communication is an important mode for assessing students’ emerging understandings.

- **Teachers facilitate and guide student work**
  Teachers participate in various ways in students’ learning activities: motivating, facilitating, and guiding students in their construction of knowledge and their social interactions with other students. Teachers need to gauge student understanding and progress, and to provide direction and feedback about their work [12].

- **Curricular activity structures shape tool use**
  The use of any software is always situated in the broader context of a task. With computer-based activities in particular, the ways in which software tools are used or not used are determined by the activity structures of the classroom, and the values assigned within these structures to different kinds of work.

DESIGN ELEMENTS FOR REFLECTIVE INQUIRY
Tools for Promoting Reflective Inquiry

Learning the reflective mode of inquiry required for open-ended investigations in complex environments means students must become effective story-tellers, or historians, of their work. They must learn to describe important features of their inquiry experiences to peers and teachers in order to explore conceptual issues and make informed decisions during their investigations. This kind of activity requires at least three key skill sets:

1. Documenting inquiry actions and understandings while working;
2. Organizing and making sense of these documented elements of inquiry;
3. Describing inquiry processes and products.

In this section we describe the role that each of these skills plays in reflective inquiry, the design features of the Progress Portfolio that support their acquisition, and the ways that these software tools are designed to work in the classroom environment.

1. **Documenting inquiry actions and understandings**
   The processes of inquiry — e.g. decisions made during inquiry, changes in understandings, and data-gathering strategies — are normally invisible aspects of investi-
gations. To tell the story of their investigation and reflect on their reasoning, students need something concrete and visible to refer to. Students must learn to work like scientists, computer programmers, writers, and other reflective professionals who need to document their own work and thinking [15]. This documentation includes records of intermediate work products and records of the thinking around these products.

The Progress Portfolio provides students with a data collection tool called the Data Camera for documenting their work products. The Data Camera “floats” on top of the screen and is always accessible while working in other applications (see Figure 1). Students document their work by using the Data Camera to capture screen images of their activity from an investigation environment. These captured images are then stored in the Progress Portfolio. In this way, students begin the process of accumulating investigation artifacts that provide a record of their intermediate work products to document the progress of their investigations.

![Figure 1. The Data Camera being used to capture a temperature map from an earth sciences visualization environment (WorldWatcher).](image)

In addition to collecting records of their work products as they proceed in their investigations, students also need to record a history of their thinking around these items. Once students have captured an image, they can attach a record of their thinking directly to it by using the Progress Portfolio’s note tool to attach colored “sticky” notes to the images. These notes also have arrows to point out key features of an image (see Figure 2, where students are using notes and arrows to describe the similarities of two fingerprints), and can be labeled to serve different documentation purposes. For example, yellow notes might be labeled “Questions” and blue notes “Evidence of...” Alternatively, note labels can be used to denote authorship when working collaboratively (e.g. Javier might use purple “Javier” notes, and Tanisha blue “Tanisha” notes).

The Progress Portfolio also provides drawing tools that give students the ability to visually describe their thinking by drawing directly on top of images. For example, students can draw a thick red line on a map to indicate where they believe a tectonic plate boundary is located an investigation map.

With the note and drawing tools students can begin to document what they were doing and thinking about as they conducted their investigation. Combined with the raw investigation artifacts collected by the Data Camera, these captured images and annotations of reasoning provide students with a tangible representation of their inquiry process — they provide students with objects to reflect on and work with.

![Figure 2. Students comparing and annotating fingerprint images in a “Crime Scene” investigation. The arrows are pointing to features that provide evidence that the two fingerprints belong to the same person.](image)

2. Organizing and making sense of the elements of inquiry

In addition to documenting, reflective inquiry demands that students also organize and make sense of their investigation artifacts. The act of organizing and reorganizing work artifacts is a step towards the goal of constructing an investigation history. This process provides important opportunities for reflection. Making decisions (e.g. how to group data items, what relation a particular artifact has to an investigation, and how to name or where to store an item) requires students to step back from their immediate work and reflect on their purpose. Negotiating these management decisions with collaborators requires additional reflection on the relative merit of a variety of ideas about managing information.

The Progress Portfolio provides three main structures for reflective management of information: pages, templates, and clusters.

Pages are the basic structural unit of the Progress Portfolio. A page is a container for a set of captured data images, annotations (notes and drawings) on and around these images, and text entry fields. Annotations are suited for shorter text that can be moved around on a page, while text fields provide a more permanent area for recording lengthier descriptions and other information.

Templates are predesigned page types, which structure the items arranged on a given page to help students focus on important aspects of their data collection and analysis. Various types of templates can be created by activity designers, teachers, or students to enable users to quickly construct a page with specific items on it (e.g. a “compare trials” page, such as Figure 3, designed by students to ease the task of comparing of 3 sound waves). The text entry fields on templates can be used to structure students’ documentation strategies by designating names for particular fields to prompt students to record their thinking and observations (e.g., a “Next steps” field, or an “Amplitude of wave” field). These text entry fields can also be used by the teacher to prompt specific reflections and observations from students, such as “How does this relate to your research question?” or more specifically “What can you predict about this animal’s offspring from its genotype?” The flexibility of the templates allows teachers and designers to tailor templates so that they target specific
inquiry skills in specific investigation environments, e.g. data collecting strategies with WorldWatcher. Page templates prompt students to consistently consider elements of an investigation as they collect data.

Clusters are collections of pages that students group together thematically, chronologically, or by some other organizational scheme (e.g. students can put all “temperature data” maps into one cluster, and “elevation data” maps into another). As students capture more and more images, their collections may contain dozens of pages, making it difficult to locate things and make sense of them. Grouping pages into clusters allows students to break down the collection into more manageable subgroups. These groups are essentially collections of pages that represent significant events in their investigative process.

3. Describing inquiry processes and products

In order for students to learn reflective inquiry practices, they need to engage in discussions with the teacher and with each other about the process of inquiry. Presenting the story of one’s inquiry is one way to promote this interaction. The Progress Portfolio provides a presentation tool that allows students to easily create a “slide-show” presentation from the pages and clusters of their collections. The presentation tool provides a simple interface to allow students to quickly create presentation slides from their collected pages, fine tune their presentation, and easily page through the slides as they present their report. The process of creating such a presentation prompts students to reflect as they revisit the history of their investigation, making decisions about which aspects of their investigation tell the best story. The process of preparing a report becomes the process of organizing a history of their investigation, promoting reflection on inquiry processes.

Together, the various tools of the Progress Portfolio help students to document and tell the story of their investigation, and reflect on their activities and thinking as they work. In this way, the Progress Portfolio not only helps students to be successful in their investigations, but also helps them learn to be reflective inquirers.

Integration of the Progress Portfolio Design with the Classroom Context

How does the design of the Progress Portfolio promote reflective inquiry in the context of classroom activities? The value of the Progress Portfolio in promoting reflective inquiry does not come from any particular tool provided by the software, but rather from the mode of student work that the suite of tools affords in the classroom context. We discuss these affordances below, in terms of the four characteristics of classroom-centered design outlined earlier: collaboration, communication, teacher facilitation, and classroom activity structures.

Supporting Collaboration in the Classroom

Reflection is not a solitary process [4; 14]. As students proceed through their inquiry investigations, their work in the Progress Portfolio promotes collaborative reflection. Constructing a representative history of their investigation can be a highly collaborative process. Students take on different roles as they collaborate around the computer, some doing the data gathering, others concentrating on documenting and presenting their results. The “off-the-shelf” investigation tools encourage students to think about and work with the low-level details of their investigation, and the Progress Portfolio tools encourage students to think about and work with more meta-level aspects of their investigation. Invisible group processes are transformed into tangible records of shared work as group members manipulate and document their thinking. The Progress Portfolio encourages a collaborative mode of work by providing tools and artifacts that can capture the collaborative process and focus the activity of group members on various key aspects of the investigation.

Supporting Communication in the Classroom

The construction of this public work record, or public knowledge base, can serve as the catalyst for conversations about reflective practice, instigating discussions of meaning, interpretation, and investigation plans with peers and teachers [13]. As students construct artifacts that represent the history of their investigation, they must negotiate an agreed-upon articulation of their story, e.g. “What should we write down for this set of data?” “How should we organize this?” “Should we present this part of our investigation?”

Figure 3. A page from a Progress Portfolio investigation displaying three captured data images from a visualization environment (Sound 3.0.1), annotations recording sound frequencies, and a customized “Observations” text entry field with student comments.

As students work through an investigation, pages provide the basic repository for individual investigation artifacts and documentation of reasoning. Templates provide a way for both teachers and students to structure pages and target reasoning and inquiry strategies around work with pages. Clusters allow students to organize their collections of pages to manage large collections of data, and to review and deconstruct their investigation. Together with the documentation tools of the Progress Portfolio, these organization tools provide students with tangible, manipulable artifacts to help them reflect on and compose a story of their investigation.

Supporting Collaboration in the Classroom

Reflection is not a solitary process [4; 14]. As students proceed through their inquiry investigations, their work in the Progress Portfolio promotes collaborative reflection. Constructing a representative history of their investigation can be a highly collaborative process. Students take on different roles as they collaborate around the computer, some doing the data gathering, others concentrating on documenting and presenting their results. The “off-the-shelf” investigation tools encourage students to think about and work with the low-level details of their investigation, and the Progress Portfolio tools encourage students to think about and work with more meta-level aspects of their investigation. Invisible group processes are transformed into tangible records of shared work as group members manipulate and document their thinking. The Progress Portfolio encourages a collaborative mode of work by providing tools and artifacts that can capture the collaborative process and focus the activity of group members on various key aspects of the investigation.

Supporting Communication in the Classroom

The construction of this public work record, or public knowledge base, can serve as the catalyst for conversations about reflective practice, instigating discussions of meaning, interpretation, and investigation plans with peers and teachers [13]. As students construct artifacts that represent the history of their investigation, they must negotiate an agreed-upon articulation of their story, e.g. “What should we write down for this set of data?” “How should we organize this?” “Should we present this part of our investigation?”
The tangible products of their work and thinking provide the basis for communication about the process of inquiry. While there is a language for talking about work products in schools (e.g. final reports, worksheets, correct and incorrect answers), students are much less accustomed to describing their ephemeral work processes. The Progress Portfolio provides students and teachers with artifacts that can be used as referents in classroom discourse, to help students to describe their thinking and inquiry actions clearly and to illustrate their descriptions in detail using their collected artifacts. Teachers can also use these artifacts to prompt students to share their thinking, and to target problem areas in student work — “What were you thinking here? And then what did that show you?”

**Supporting Teacher Facilitation and Guidance**

The Progress Portfolio is not just a tool for students: it is also a tool that addresses the needs of teachers to guide and assess student work. The teacher is responsible for setting an atmosphere of reflective inquiry in the classroom. By facilitating and guiding student activities, the teacher instills reflective practices in students. The tools of the Progress Portfolio support teachers in their task of facilitation by helping them structure students’ activities in investigation environments. Organizing structures like pages, templates, and clusters help to decompose the task of information management into understandable subtasks for students, scaffolding the activities of reconsidering and sorting sets of information. Through the use of various customized templates, teachers can emphasize different project tasks and knowledge work. For example, a template might ask students to simply record data that they have generated, or to draw generalizations from data.

In classrooms, teachers also need to gauge student work. Teachers can use the results of student work with documentation tools for assessing student understanding, assessing effort, and evaluating their own teaching. The documentation tools of the Progress Portfolio provide teachers with opportunities for new forms of assessment that value the process as well as the products of an investigation. By providing images and annotations showing the interim states of students’ project work, the Progress Portfolio can encourage teachers to emphasize aspects of the practice of reflective inquiry that are ordinarily difficult to make clear to students, or that might even be absent from prior classroom instruction.

**Supporting Classroom Activity Structures**

As new kinds of products and processes are valued in the science classroom — such as explanations of inquiry processes, including mistakes and dead-ends — the Progress Portfolio makes these products and processes tangible to students and teachers as objects of reflection. In this way the Progress Portfolio can support the instructional goals of new inquiry-based curricula and standards, affording the kinds of actions with data that students are expected to master to be effective inquirers.

The flexibility and customizability of the Progress Portfolio allows teachers to use it with different inquiry projects over the course of the school year. Ideally, inquiry investigations in classrooms should not be a one-time activity, but rather something that teachers build up to and revisit. The Progress Portfolio provides a consistent set of tools and activities for working with and talking about inquiry across these diverse inquiry projects. In this way, teachers can help students to learn the skills of reflective inquiry, and revisit these skills over time. Teachers can also integrate the use of the Progress Portfolio into the larger patterns of classroom activity throughout a school year to support student inquiry.

**EARLY EXPERIENCE: EXPLORING STRUCTURE**

We have had a number of different populations use the Progress Portfolio in order to test the usability of the software, ensure its appropriateness for different contexts, and identify new functionality required by these contexts. In this section we describe the evolution of the Progress Portfolio through these early experiences with middle school students, high school students, and teachers. In particular, we describe how the demands of the classroom highlighted the need to structure student work using the software, and the tradeoffs involved in designing the constraints and affordances of the tools for this purpose.

**Middle School: The Need to Structure**

Our first trial with an early prototype of the software involved 6 middle school students over six one-hour after-school sessions [8]. The primary goal of this trial was to see whether students could understand the functionality of the tools and use them effectively. We designed a series of activities to engage students in the process of capturing and annotating images from different sources, e.g. a data visualizer (WorldWatcher) and a web browser (Netscape).

As a result of these activities, we noticed that students needed help with the process of capturing and annotating. In the activities we set up, we wanted students to reflect as they were working with image-based data. For example, students constructed their own reviews of web sites. We wanted them to document why they thought a site was a good or bad, e.g. rating the quality of the information, the quality of the graphics, etc. But students tended to be very action-oriented, flitting from page to page and occasionally capturing information, but leaving no record of their thoughts about each page. We had to constantly remind them to write down what they found interesting and why. The tool needed to scaffold students in their capturing and annotation work.

The main way in which this early prototype Progress Portfolio structured activity was with named sticky-note types. Labeling a note as a “Question” or “Observation” note could encourage students to think about recording their questions and observations on the page, but we realized that students needed more explicit structuring, and there needed to be a more permanent repository of annotations. We also realized that students were being distracted by the need to arrange the elements on a page every time an image was captured (e.g. the captured images and notes). To address these issues, we added the functionality of templates, which structure student work via text prompts that remind them to document particular aspects of their investigation (e.g.
“Why do you think this web site is good?”), text-entry fields for students to enter more extended and permanent annotations, and a fixed page layout of the image and text fields to ease the burden of arranging the page elements.

Another realization that came out of the middle school studies was the need for a final product of the inquiry that could be created in the Progress Portfolio to help students communicate about their investigation. Having completed an investigation, students had difficulty with the process of telling a story about their work without getting bogged down in the activity of opening and closing pages and recounting every detail of their investigation. So we designed presentation tools to structure an activity where students needed to review and reflect on the details of their investigation, then construct presentation slides from their pages to communicate a coherent story about their investigation. From the insights gained with the middle school students, we redesigned the Progress Portfolio to add more structure to student activities using templates and presentation tools.

High School: Too Much Structure and the Role of Teachers in Structuring

We used this new more structured version of the Progress Portfolio with high school students in a regular classroom setting. The goal of this trial was to see if the mode of work and the kinds of interactions supported by the Progress Portfolio were amenable to an in-school activity directed by a teacher rather than researchers. Two small groups of students in high school physics classes used the Progress Portfolio over a period of 6 weeks as part of a long-term physics inquiry project. This included a literature search, a computer-based physics experiment, an oral presentation, a final written report, and interim milestones.

One of the two groups (2 seniors and 1 junior) used the Progress Portfolio in conjunction with a simulation environment, Interactive Physics, to investigate the nature of Pluto’s chaotic orbit around the sun. The other group (2 seniors and 2 juniors) used the Progress Portfolio with a sound wave visualizer, Sound 3.0.1, to investigate relationships between the sound waves of notes played on two instruments, and to support the design of a novel instrument.

Both groups successfully used the Progress Portfolio to document their literature search of online resources, document their investigations in their respective investigation environments by capturing and annotating data, and create presentations describing the history of their investigation, showing artifacts they collected along the way [8]. The process of creating a presentation relating their investigation prompted the students to review the history of their investigation and reflect on how to tell the best story about their process. This process facilitated reflective conversations with the teacher about the significance and interpretations of their investigative process and findings.

We found that templates in particular were effective in structuring the documentation process and supporting reflection. The teacher-designed page templates prompted students to record information such as data sources (e.g. “sound wave generated by a flute, playing the note A, using the following fingering”), and specific measurements made in the investigation environment (e.g. “The frequency of this flute A is .83 KHz, the wavelength is 1.2 ms, and the amplitude is 40.”). Additionally, students used the templates to structure their own analytic process. The “Music Group” (using Sound 3.0.1) wanted to compare the similarities and differences of the sound waves generated by their three instruments. To that end, they designed a page template that allowed them to easily construct comparisons across the three waves (see Figure 3). The process of creating the template itself also prompted them to reflect on their data collection strategies as they negotiated within their group about how to design this page template and how to gather their data.

While templates helped structure the documentation process, the students often found them to be too restrictive. We designed the templates to “lock-down” what could and could not be on a page (e.g. number, size and position of images and text boxes). We did not want students to waste time playing with the layout of the page nor arbitrarily deleting teachers’ prompts that they did not want to deal with. Instead, we wanted them to focus on the task at hand, documenting and reflecting on their work. But this design also meant that students could not easily add additional text or images to a page beyond those provided by the template, short of creating a whole new template. The students we worked with found that they needed more flexibility in changing the structure of pages on-the-fly (e.g. needing to add an extra text box to describe the physical construction of the flute) without having to change the basic design of that page template. Thus, while structuring student work with templates was helpful, having too much structure could also hinder student work. We are now engaged in the process of redesigning the tools to provide both flexibility and structure.

As we observed students interacting with the software and the teacher, it became clear that teachers structured student work much more than the software did. The mode of use of the software is greatly shaped by the teacher, and the teacher plays a crucial role in guiding students to be reflective with the tools provided. The ways in which students use the Progress Portfolio are intimately tied to the value system that the teacher establishes for the classroom.

For example, we find that students are masters of efficiency — unless there is a tangible benefit to a task, they won’t do it. It needs to be made clear to the student that capturing the process of their work has a payoff, e.g. it will make it easier to create their presentation, which will in turn help their performance and grade in the class. This payoff needs to be designed into the activity structure, to instill a sense of the real value of reflection in generating worthwhile products and understandings. For instance, students can be instructed to capture data at certain set intervals when they first begin using the Progress Portfolio; this artificial constraint on their use of the tool can then be lifted as they become familiar with what kinds of captured data are more and less helpful to them and they begin to construct their own sense of what is valuable to capture.
Teachers: Structuring Progress Portfolio Activities

We conducted a teacher workshop with six elementary, middle, and high school teachers to explore how the design of curriculum activities and the Progress Portfolio software could structure student work. Groups of teachers were engaged in a day-long session of exploration and design of curricular activities for their classrooms, ranging from reworking existing curricula for use with the Progress Portfolio, to generating completely new curriculum ideas.

Teachers saw benefits and applicability of the software

All of the teachers we worked with saw clear advantages to using the software, and how it fit into or extended their curricular activities. They talked about the ability of the tool to bring attention from “lower order thinking” to “higher order thinking” as students create, manipulate, document, and reflect with the Progress Portfolio.

The teachers reported that while collaborative inquiry work gave them a sense of the general level of understanding in the class, assessing the understanding level of individuals was much more difficult because of the invisibility of individual student work. They felt that the Progress Portfolio could provide a way for individuals to leave a record of their work, even while working in groups, thus providing an assessment mechanism that can tap into individual student understanding in a manner that is otherwise difficult in project-oriented classrooms.

Teachers’ approaches to using the tool for structuring

The teachers also designed activities to use the Progress Portfolio tools to structure student work. One group of teachers in particular thought about how they could teach the students to use the software and to be reflective as they worked. The teachers designed an activity that started with two visualization images already captured in the Progress Portfolio for the students, allowing students to focus on the knowledge activities around these images — i.e. comparing and contrasting, documenting observations and interpretations — to begin to learn how to use the Progress Portfolio tools. The activity would then lead students into capturing their own images and conducting their own investigations. The teachers also designed templates and pages that encouraged students to compare and contrast two different data visualizations, with prompts like “What do you see?” “How are they different?” and “Why?” These pages were designed not only to help students think about data, but also to help them learn the mode of work of the Progress Portfolio (see Figure 4). In this way, teachers could structure classroom activities that both introduce the tools and teach an appropriate mode of work.

Teachers mapping the tool to their classroom practices

The teachers also drew from their own toolkit of learning activities, suggesting ways in which the Progress Portfolio might be made to take advantage of both the reflective tools it provides and the learning activities that the teachers currently enact in their classrooms. Two teachers talked about their use of graphic organizers to help students think about the relationships between objects and ideas. Graphic organizers are essentially epistemic forms [3] such as lists, tables, trees, cycles, timelines, flowcharts, etc., that people use to organize and look for relationships in information. The clusters, or lists, provided by the Progress Portfolio offer a primitive epistemic form for organizing data. Adding more graphic organizers to the Progress Portfolio could structure activities by giving students different ways for manipulating the records that they collect, as well as to represent their understanding in alternative ways, e.g. exploring visual and spatial relationships.

This takes an existing classroom practice and replicates it on the computer, extending it by taking advantage of the power offered by the computer to access and manipulate large amounts of information. For example, students could build concept maps of the data they collect to represent how items are related to each other, or they could use a table to construct a series of comparisons across data points. The addition of such graphic organizers to the Progress Portfolio would offer students and teachers a new way to think about the concepts and processes of investigations.

Designing supports for the classroom context requires attention to the issue of structuring classroom activities. As discussed above, this structuring can take place in the software, in the activities set in motion by teachers, or under the direction of the teachers themselves. Finding the right level of structuring in the software remains a challenge. It requires an exploration of the tradeoffs between maintaining enough flexibility to support different modes of work, yet remaining structured enough to successfully guide students to be reflective in their work. It also requires...
attention to the structuring influences outside the software, in particular, the structure provided by the existing classroom practices of teachers and the affordances of the software to support these contexts.

**DISCUSSION**

Our approach to designing reflective supports for classroom inquiry, embodied in the Progress Portfolio, has shown promise in early implementation trials. Both students and teachers demonstrated that they were able to understand the purpose of the tools and to use them effectively. These trials have suggested a number of possible directions for us to pursue in redesigning the tools to better promote reflective inquiry in classrooms.

In addition to its utility for students and teachers, this basic toolkit for reflection also has potential beyond the classroom. The need to be reflective inquirers is not limited to just schools. Schön [14] has described reflective practices in the workplace across a variety of professions. In particular, this mode of reflection centered around artifacts that represent the process of work is widespread. For example, architects’ preliminary sketches and drafts provide a documentation of the development of ideas around which both novices and experts discuss issues of designs and tradeoffs. Similarly, design rationale research is concerned with making rationale apparent for the design community.

Our classroom-centered design process is intended to bring these tools and this mode of work effectively into the world of schooling, so that students may acquire these important skills, and apply them in the classroom and elsewhere. However, the class of tools provided by the Progress Portfolio — capture, annotation and organization tools for creating artifacts that represent a process, and imbuing them with the rationale behind their creation — has potential applicability to a wide range of work contexts in which the intermediate products of work are unavailable for inspection. We believe that the design described here suggests promising directions for future work.

**ACKNOWLEDGMENTS**

We are grateful to our teacher-collaborators: Laura Walhoff, Jennifer Munnit, Judy Whitcomb, Marilyn Havlik, Kim Alam, Albert Delgado, and John Leary; and to Diana Joseph, Brian K. Smith, and Iris Tabak for comments. This work is funded by DARPA/CAETI No. N66001-95-C-8630 and NSF Grant Nos. 9720377 and 9454155.

**REFERENCES**