ScribbleProv: Supporting Disciplined Improvisation During Face-to-Face Discussion

YEAR 2 REPORT: ACTIVITIES

We describe the activities conducted during the second year of the ScribbleProv project in terms of 6 activities: theory refinement, software development, activity development, implementation and evaluation, synergistic activities, and dissemination and outreach. In summary, we:

- Generalized our work to a new domain (earth science), a new NSF-funded curriculum, and a new set of teachers who are explicitly enacting "contingent teaching"—that is, continually assessing what students know and adjusting instruction (improvising) based upon that understanding.
- Implemented most of the Group Scribbles extensions and refinements derived from our Year 1 analysis to help the teacher frame and respond creatively to the classroom discussion.
- Distributed the Group Scribbles source code to several partner organizations, and made the Group Scribbles software, along with user and developer support documentation, available for download on the public Group Scribbles community wiki.
- Collaborated with teachers and another NSF-funded project to design several new Group Scribbles activities and study use of the activities in pilot tests and classroom studies.
- Led a full-day workshop at the June 2009 international conference on Computer Supported Collaborative Learning (CSCL), titled "Agile Learning and Collaboration-Improvisational Uses of Group Scribbles and Other CSCL Tools."
- Promoted the software, activities, and finding through several forums, including a newsletter, a project web site, a community wiki space, and presentations.
- Collaborated with many researchers, K-12 teachers, and students from around the world—including the U.S., Singapore, Spain, Taiwan, and England—providing professional development and training opportunities and resulting new conference papers and book chapters.

Activity 1: Theory Refinement

In our Year 1 work, we found that teachers do use improvisational moves frequently, but they also explicitly break rules of (theatrical) improvisation just as frequently. We documented how improvisational techniques are enacted, modified, and augmented in the classroom, and derived, based upon our analysis, a number of extensions and refinements to Group Scribbles so that it can better support productive collaborative activities, particularly when teachers need to make real-time accommodations to student contributions. Most of these extensions were implemented in Year 2 (see Activity 2, Software Development, below). In Year 1, we also reported that a group of evaluation experts suggested that we consider enhancing existing, classroom-tested curricula with Group Scribbles activities and assess the value added. In Year 2, we began to enhance a popular earth-science curriculum with Group Scribbles activities, while continuing to observe our partner middle-school mathematics teachers using Group Scribbles activities in their classroom.

We originally proposed to test the generality of our theory and technology beyond the collaborative learning in mathematics classrooms by conducting participatory design studies of Group Scribbles with small teams of undergraduate students enrolled in a human-computer

interaction course at the University of Colorado at Boulder. In Year 2, we altered our plan by instead testing generality in a different domain—middle school earth science—based upon several confluences: concerns voiced by proposal reviewers about the proposed study at UC Boulder and loss of our key tie (Chris DiGiano) to UC Bounder, recommendations from evaluation experts during Year 1 to study Group Scribbles in the context of existing classroom-tested curriculum (as mentioned above), and an opportunity to work with a willing partner in the NSF-funded Contingent Pedagogies project that would allow us to generalize our work to a new domain (earth science), new curriculum, and new set of teachers who are explicitly enacting contingent teaching—that is, continually assessing what students know and adjusting instruction based upon that.

The Contingent Pedagogies project is using formative assessment and classroom network technologies (clickers and Group Scribbles) to help teachers adjust instruction in reaction to student feedback in order to improve middle school student learning of selected earth science concepts (e.g., the rock cycle, forces that shape Earth's surface, and plate tectonics). The term "contingent" is used because what and how teachers teach should be *contingent* upon what assessments tell teachers about what their students know and can do. That is, when teachers improvise in reaction to student input or breakdowns in the classroom, the moves they employ should vary depending on what their students know and can do. While network technology can support classroom participation and motivate students, success is dependent upon teachers posing good questions, structuring activities to facilitate feedback, and having resources that allow them to adjust instruction, contingent upon what they find out students know and can do (Beatty, Gerace, Leonard, & Dufresne, 2006). Flexible *pedagogical design patterns* can help manage complexity and structure activities in a way that increases opportunities for student feedback to support contingent teaching.

Pedagogical design patterns are a sequence of teaching moves that a teacher can repeat, regardless of what the subject matter is, to help manage the flow of work, increase student opportunities to communicate with the teacher and with peers about their thinking, motivate students to want to participate, and to provide the teacher with clear points of feedback to use to adjust instruction based upon student reaction or breakdowns in the classroom. Penuel et al (2007) summarizes a number of pedagogical practices employed by K-12 teachers conjunction with response system use. Teachers report that networking technologies are readily implemented into pedagogical patterns (Penuel et al., 2007). The structure imposed by pedagogical patterns is not intended to limit creativity—on the contrary, by managing the flow of work, good patterns ensure opportunities for student input and reduce cognitive load on the teacher so that she can better attend to student feedback, elevating classroom conversations to a higher level (DiGiano, Yarnall, Patton, Roschelle, Tatar, & Manley, 2002).

In Year 2, the ScribbleProv team collaborated with the Contingent Pedagogies team to (a) identify and document pedagogical patterns that increase opportunities for student feedback to support contingent teaching when using Group Scribbles (see Finding 1: Theory Development), and (b) co-design, with teachers, Group Scribbles activities that enact these patterns (see Activity 3: Activity Development). The topic of collaborative pedagogical patterns will also likely be a focus at our summer CSCL workshop (see Dissemination and Outreach Activities, below).

Activity 2: Software Development

New Features

The theoretical understandings derived from our analysis in Year 1 suggested eight new extensions and refinements to Group Scribbles to better support collaborative activities, particularly when teachers need to make real-time accommodations to a breakdown that triggers a change in approach. Five of the eight new features derived from the theoretical framework were implemented in Year 2:

- Support for lightweight constraints. A new set of controls allows teachers to configure and change (on the fly) student access to the public board (freezing, drawing, masking)
- Activity templates. With the new template feature teacher can build libraries of activity templates, and instantiate a template to produce a new, pre-configured collection of boards, scribbles, and tokens.
- Indication (pointing). The Spotlight feature allows the teacher to indicate interest in specific board contents.
- Lifting a group of scribbles to new group/public board. A new multi-select and drag feature allows teachers and students to select and move a group of scribbles in unison to a new location or new board.
- Highlighting group work. The default board layout allows view of private board, public board, and up to two group boards at a time.

Designs for the remaining 3 suggested improvements (enhanced activity management, smooth transitions to activities and back, smart backgrounds) are being discussed with our research partners in Singapore (see Synergistic Activities, below), who plan to implement at least the first two features and contribute them back to the Group Scribbles code base.

Software and Source Code Distributions

Group Scribbles 2.0 (GS2) was released for private beta testing in December 2008, and a public binary version was released to via the Group Scribbles Community Wiki (see Activity 6, Dissemination and Outreach) in February 2008. We also streamlined the development process and now offer a source code license agreement (also available on the Community Wiki) for individuals and organizations. So far, SRI has distributed the source code to four different organizations (research partners in Spain, Taiwan, U.K., and Singapore) that have requested access. Licensees are encouraged, but not required, to contribute code back to SRI's Group Scribbles project, but our research partners have indicated that they intend to contribute back code and collaborate closely with us on interaction design for new functionality.

User Guide

A Group Scribbles User Guide was developed and made available to the public on the Community Wiki. For teachers, the guide covers steps creating classrooms, accounts, and activities, and how to use the spotlight tool and various board controls to add background images, clean or delete boards, or change student view or access a board (e.g., toggle their ability to draw on the board or interact with it entirely, or mask scribbles so that their content is hidden). For students and other users, the guide covers steps to log in and choose a classroom and activity, reviews the screen layout and toolbar options, and describes how to use scribbles and

scribble pads, annotate with labels, and manipulate the board layout to view more than two boards a time.

Activity 3: Activity Development

Three San Francisco Bay Area middle and high school math teachers, Lynn Eisner, Chrystine Lee, and Bonnie Lake, interned with the ScribbleProv project at SRI over the summer through the Industry Initiatives for Science and Math Education (IISME) Fellowship Program for Teachers. IISME is a nonprofit collaborative of San Francisco Bay Area corporations, universities, and local educators working to improve mathematics and science education. The teachers worked with each other and with the ScribbleProv team to create 13 new Group Scribbles math activities (see Findings: Table 3), with the intent that the ScribbleProv team would conduct observations as the teachers used some of these activities in their classrooms during the 2008-2009 school year (See Activity 4, Implementation and Evaluation, below).

In addition, our project team collaborated with the Contingent Pedagogies project (see Activity 1 and Synergistic Activities, below), together creating 14 middle school earth science activities that use Group Scribbles and implement pedagogical design patterns identified by our teams (see Findings: Table 4). Pilot testing of these activities and patterns began this spring and will continue through the year.

Activity 4: Implementation and Evaluation

During the second year of the project, several Group Scribbles research studies were conducted by the ScribbleProv team and by our colleagues around the world (see Activities by Research Colleagues under Activity 6, below). For example, colleagues at the National Institute of Education in Singapore explored Group Scribbles in supporting Jigsaw cooperative learning in a graduate course; colleagues at the University of Nottingham, UK, explored Group Scribbles with tablet PCs to support collaborative learning of English vocabulary; and colleagues at the University of Valladolid, Spain, use Group Scribbles to study design tensions between socially-mediated and technology-mediated coordination using Jigsaw and Pyramid collaboration patterns. The ScribbleProv project supports such research by providing access to Group Scribbles software, source code, user guides, and activities on the community wiki, and providing information on our work and feedback on their research.

The ScribbleProv team observed several pilot and classroom implementations of Group Scribbles activities by our partner middle school math and earth science teachers in the first 9 months of Year 2 (see Table 1 below). In each of these implementations, the instructor began by engaging participants in a practice activity (e.g., writing their name on a scribble and dragging it to the public space) and then led participants through one or two activities. At the end of each implementation, interviews were conducted with the teacher and some of the students. Lessons learned from these pilot studies and implementations are described in the Findings section of this report.

Table 1. Group Scribbles implementations in the first 9 months of Year 2 of the project (implementations will continue into the summer and fall).

When	Topic	Length	Participants	Activities
Nov 13 2008	Math	50 min	11 7th grade students (low-performing class)	Race to the Millionth, Missing Operators
Feb 20 2009	Earth science	1 hr	18 adults (workshop participants)	Earthquakes and Volcanoes
April 9 2009	Earth science	1 hr	6 adults (pilot study)	Researching Rock Types
April 24 2009	Math	50 min	10 6th grade students (low-performing class)	Race to the Millionth
May 21 2009	Earth science	2 hrs	8 adults (pilot study)	Waves and Wave Speed, Deposition
June 2 2009	Earth science	50 min (x 2)	60 7th grade students (2 classrooms)	(TBD — in the future)

Activity 5: Synergistic Activities

Contingent Pedagogies Project

The NSF-funded Contingent Pedagogies project led by Bill Penuel and Angela Haydel-Debarger at SRI hosted a 2-day design workshop in February 2009 to develop earth science activities that use Group Scribbles and clicker technology. Workshop participants included members of both the Contingent Pedagogies and ScribbleProv teams, along with middle- and high-school teachers, curriculum developers, assessment developers, software engineers, researchers, and professional development specialists. Four multi-day Group Scribbles activities were developed, each building on the American Geological Society's Investigating Earth Systems (IES) curriculum and enacting a subset of pedagogical patterns (see Activity 1) that a teacher can repeat to help manage the flow of work, increase student opportunities to communicate, motivate students to want to participate, and to provide the teacher with clear points of feedback to use to adjust instruction. Participating teachers began testing the lessons in their classrooms in May 2009. By the end of 2009, the project team expects to develop 2-3 dozen activities and recruit and train several additional teachers for implementations studies that will begin in 2010.

National Institute of Education (NIE) Learning Sciences Lab, Nanyang University, Singapore

ScribbleProv team members continue to work with NIE under as services agreement directed by Dr. Chee-Kit Looi in Singapore. NIE is developing, implementing, and studying the effects of Group Scribbles activities in Singapore classrooms. SRI has co-authored a book chapter (submitted) with NIE staff on *Rapid Collaborative Knowledge Building* (RCKB), which is defined as face-to-face collaborative knowledge building over a short (e.g., 1-2 hr) duration, supported by a system for lightweight synchronous communication such as Group Scribbles. We are also collaborating with NIE on the design of new modules for GS for user and activity management as well as data logging and analysis.

Activity 6: Dissemination and Outreach Activities

CSCL 2009 Group Scribbles Workshop

The ScribbleProv team submitted a proposal for a full-day workshop at the June 2009 international conference on Computer Supported Collaborative Learning (CSCL), which was accepted. The workshop, titled "Agile Learning and Collaboration-Improvisational Uses of Group Scribbles and Other CSCL Tools," will bring together users and researchers from around the world to showcase Group Scribbles and other collaborative learning tools, discuss challenges of assessment and improvisational instruction, and develop design principles for producing activities that enable agile learning and collaboration in real classrooms. The workshop will begin with a background talk on the agile classroom, followed by a demonstration of Group Scribbles. Group Scribbles will be the medium via which participants receive, generate, and edit information throughout the day in their brainstorming and design sessions. Thus, the workshop itself will operate as an agile classroom. Co-organizers of the workshop are Yannis Dimitriadis at the University of Valladolid, Spain, and Raj Chaudhury at Auburn University (see "Research Colleagues" below).

Group Scribbles Web Site and Community Wiki

We continue to provide updates on the project and access to new Group Scribbles related publications on the Group Scribbles web site (groupscribbles.sri.com). Group Scribbles software, user guides, activities, and newsletters are frequently updated and available to the public on the Community Wiki (http://groupscribbles.sri.com/community.html).

Group Scribbles Newsletter and Mailing List

A semi-annual Group Scribbles newsletter with updates on activities by SRI and our colleagues is posted to the Community Wiki and sent to the community mailing list (gs-announce@ctl.sri.com) semi-annually. In the second year of the project, newsletters were sent in October 2008 and March 2009 (see headlines below). The size of the mailing list increased 75% in year 2 of the project, to 44 subscribers in Singapore, Taiwan, Spain, England, Chile, and the US.

October 2008 News

- New Group Scribbles Web Site
- Group Scribbles 2.0 (GS2) Software Development Update
- Teacher Partnerships and Activities
- ScribbleProv First Year Report Activities and Findings
- Activities By Our Colleagues
- Group Scribbles Song!

March 2009 News

- Join Us at the GS Workshop at CSCL 2009 in Greece!
- Public GS Server Binary Distribution (Beta) Available
- New GS User Guide
- GS Development Update
- ScribbleProv Research Update
- Activities By Our Colleagues

Papers and Presentations

Group Scribbles software and activities and findings were presented in seven publications in the second year of the project: five publications by external collaborators, and two (below) with co-authors from the ScribbleProv team at SRI International. Publications by SRI and our colleagues are listed (and linked to, where possible) on the Group Scribbles web site.

- Patton, C., Tatar, D., & Dimitriadis, Y. (2008). Trace theory, coordination games and Group Scribbles. In J. Voogt & G. Knezek (Eds.), *International Handbook of Information Technology in Primary and Secondary Education*, chapter on *Emerging Technologies*, 921-934. New York: Springer.
- Ng, F., Patton, C., & Looi, C. (submitted). Rapid collaborative knowledge building. To appear in an edited book on E-Collaborative Knowledge Construction published by IGI Global.

Activities by Research Colleagues

Group Scribbles is being actively used by researchers and students around the world. Activities by our international colleagues during the second year of the ScribbleProv research project are detailed below. The ScribbleProv project supports this work by providing resources on the Group Scribbles Community Wiki (e.g., software, user guides, activities, newsletter updates), a license to use the Group Scribbles source code, updates on our work (e.g., via our newsletter), and feedback on and dissemination of others' work (e.g., linking to their publications on the Group Scribbles web site, featuring their work in our newsletter).

- Yannis Dimitriadis at the University of Valladolid, Spain, and his Gsic/Emic group has initiated a medium-term research project in which they are studying improvisation, creativity, and associated design tensions using Group Scribbles through field work at the Ana de Austria primary school (K-12) at Cigales, province of Valladolid, Spain. Group Scribbles has been used in this school since December 2008 by a set of teachers (3-8) on a regular basis. Yannis is also giving an invited talk in September for the Apprentice group on Group Scribbles and the merits of supporting real-time coordination. Apprentice is a pluridisciplinary (psychology, language sciences, computer science, didactics, etc.) regional group centered in Lyon, France, that is interested in technology and learning.

- Raj Chaudhury, now at Auburn University in Alabama, submitted a proposal to the Macarthur Foundation's Digital Media and Learning Competition to fund a 2-week Participatory Learning workshop at SRI in fall 2009. If funded, the workshop will bring together teachers and researchers from around the world who have been experimenting with Group Scribbles to advance understanding of how to build adaptive teaching expertise and 21st century learner skills in an active learning environment. Raj also presented Group Scribbles at the SoTL Commons Conference in Statesboro, GA in March, and engaged participants in thinking about new ways (across disciplines) in which they could make their students' thinking visible.

- Mike Sharples and his students at the University of Nottingham have been running trials at Djanogly Academy to evaluate Group Scribbles and their SceDer system for math and science teaching. Mike and his student Jitti Niramitranon recently published a paper (with C. Greenhalgh and C. P. Lin) entitled, "SceDer and COML: Toolsets for Learning Design and Facilitation in One-to-One Technology Classroom," which is available on the Group Scribbles web site (groupscribbles.sri.com)

- Sarah Sharples (no relation to Mike) in the Human Factors Research Group at the University of Nottingham has been using Group Scribbles as part of her software design

course and as part of a project funded by HP, who donated tablet computers and some funding. They have also demoed Group Scribbles to various visitors now that they have their lab facilities and Flexible Learning Room working.

- Chiu-Pin (Robin) Lin and his students in the Graduate Institute of eLearning Technology at National Hsinchu University of Education and presented two papers on their work related to Group Scribbles at WMUTE2008 and ICALT2008: "Group Scribbles to Support Jigsaw Cooperative Learning in a Graduate Course" (ICALT2008) and "Tablet PC to Support Collaborative Learning: An Empirical Study of English Vocabulary Learning" (WMUTE2008). These papers are listed and linked to on the Group Scribbles web site (groupscribbles.sri.com)

References

Beatty, I. D., Gerace, W. J., Leonard, W. J., & Dufresne, R. J. (2006). Designing effective questions for classroom response system teaching. *American Journal of Physics, 74*(1), 31-39.

DiGiano, C., Yarnall, L., Patton, C., Roschelle, J., Tatar, D. G., & Manley, M. (2002). Collaboration design patterns: Conceptual tools for planning for the wireless classroom. In *Proceedings of WMTE 2002* (pp. 39-47).

Penuel, W. R., Boscardin, C. K., Masyn, K., & Crawford, V. M. (2007). Teaching with student response systems in elementary and secondary education settings: A survey study. *Educational Technology Research and Development, 55*(4), 315-346.

Penuel, W. R., Roschelle, J., & Shechtman, N. (2007). The WHIRL co-design process: Participant experiences. *Research and Practice in Technology Enhanced Learning, 2*(1), 51-74.

ScribbleProv: Supporting Disciplined Improvisation During Face-to-Face Discussion

YEAR 1 REPORT: FINDINGS

We categorize the results from the second year of the grant in terms of three main findings: identification and development of useful pedagogical patterns, activities developed, and pilot and classroom implementation findings. In summary, we:

- Identified and elaborated 10 pedagogical patterns to increase the opportunities for students to communicate with their teacher and peers about their thinking and increase feedback to the teacher about student understanding to support contingent teaching with Group Scribbles.
- Developed 27 new middle school activities (13 math, 14 earth science) that use Group Scribbles and implement one or more pedagogical design patterns.
- Observed pilot and classroom implementations of the new Group Scribbles activities and revised the activities (e.g., clarifying instructions, changing representations or procedures) to address observed difficulties.
- Documented key findings, such as observed challenges in moving students to and from individual, group, and class level interactions as well as special difficulties for younger students collaborating in a whole-class (vs. small-group) settings; Group Scribbles may offer an opportunity for students to learn and practice collaboration skills through more continuous use, perhaps in conjunction with more formal training on collaboration skills.

Finding 1: Pedagogical Patterns

Table 2 summarizes the pedagogical patterns that we identified or developed in Year 2 to (1) increase the opportunities for students to communicate with their teacher and peers about their thinking, and (2) increase feedback to the teacher about student understanding to support productive, contingent teaching with Group Scribbles.

These patterns use a variety of group structures (whole class, small group, pair, and individual) alone or in sequence, leverage Group Scribbles software features, and have been instantiated across several activities developed for use in our middle school math and earth science classrooms (although a few patterns, e.g., those related to experimental investigations, are currently only enacted in the earth science activities).

Future work in 2009 (and beyond, with the Contingent Pedagogies project) will look at how often and how reliably teachers integrate the patterns into their instruction with Group Scribbles, which patterns are most effective for supporting contingent teaching, and teacher perceptions of the software and patterns and their impact on teacher moves and student learning.

Table 2. Pedagogical patterns designed to increase the opportunities for student to about their thinking and increase feedback to support contingent, improvisational teaching.

Pattern Name	Description	Communication and Feedback Opportunities
Question/ Info Posing	Individually or in small groups, students generate questions or items for consideration relative to	Provides students with opportunities to design questions for investigation and see how their work compares with work by

	some topic, and then all students are involved in reviewing the items (and perhaps categorizing them, see Organize It).	their peers, and provide teachers with feedback on student conceptions that need to be addressed.
Organize It	Students organize scribbles on a public board (e.g., questions, concepts, numbers) into categories, hierarchies, rankings, or numerical order.	Provides students with opportunities to understand concepts through evaluating and sorting them, and provides teachers with feedback on student understandings of the relationships between items.
Where on this Image?	The instructor poses an inquiry, and students respond by marking up or placing tokens on an image in the public space.	Provides opportunities for students to communicate their understanding about relationships between concepts, and provide teachers with feedback about students' abilities to compare and contrast.
Distributed Problem Solving	Each student takes a scribble from the public board (a prompt, number, question, etc.), creates a response in their private space (an answer, another question, a new idea), and then posts it to the public board.	Provides opportunities for every student to be individually accountable for some portion of a task (the overall goal requires all students's contributions), and provides teachers with feedback about student's conceptions and ability to work as a team to solve a problem.
Collaborative Game	The instructor leads students in a collaborative game, using the public board as an information center where students post their results to be shared with other students. This may be a game that is already collaborative (such as Hangman), others that were previously individual (such as crossword puzzles or Sudoku) and adapted to be collaborative, or a new game entirely (e.g., a form of distributed problem solving.)	Provides opportunities for students to be individually accountable for some portion of a team task and perhaps take on a specialized role, and provides teachers with feedback about student's conceptions and ability to work as a team in various roles.
Pipeline	Each student takes a scribble from the public board, performs one step of a multi-step solution, and returns a scribble to the board. (E.g., if the scribble is a fraction, they may simplify it by dividing by only one factor). Similar to distributed problem solving, but may involve several iterations, and different students may take on different roles (e.g., each student is responsible for one factor, and	Provides opportunities for every student to be individually accountable for some portion of a multi-step task and (perhaps) to work at different speeds depending on their abilities. Provides teachers with feedback about student's skills and ability to work as a team to solve a problem.

	they take a fraction only when their factor would divide into it).	
Concept Mapping	Individually or in small groups, students generate concept maps for a system (e.g., a natural event, causes and effects). Students could all work on the same system or on different but related systems (e.g., half work on earthquakes, half on volcanos). All students are then involved in creating a public concept map by adding a concept and connection to the public graph and explaining it to the class.	Provide students with an opportunity to discuss how different concepts are related, and provides teachers and students with a sense of each others' thinking about the connection between concepts.
Predict with Reasons	Before an experiment, students formulate individual predictions, share and discuss their predictions in small groups, annotate them with reasons supporting the predictions, and choose the most likely prediction(s). When the investigation is over, students review the success of their predictions, review the reasoning behind the predictions, and discuss the underlying scientific significance.	Provides opportunities for students to make a prediction (stated outcome), and written reasons for the prediction, ahead of an experiment, and later compare with findings. Provides teachers with an understanding of students' conceptions of the upcoming experiment and students' scientific reasoning.
Design and Test	During an experiment, students work in small groups to design a procedure and record test options on their group board. Then, groups shares their ideas with each other. Whole group discussions and feedback provide the basis for refinements to each groups test designs, which are then shared again for comment and peer (and teacher) approval.	Provides opportunities for students to design a scientific experiment, test, model, or procedure (and perhaps also run it, and review results), and provides the teacher with an organizational framework for small group design of fair scientific testing and associated feedback through peer review.
Group Data Creation and Comparison.	In small groups, students organize data from an experiment on their group board, and discuss similarities and differences between group results as a class. appropriately described their data, and how their students review, organize, and represent data.	Provides opportunities for students to share data and discuss how to organize and compare data, and provides feedback to teachers about whether students are using tools and techniques appropriately, have

Finding 2: Activities Developed

Twenty-seven new activities were developed in Year 2, including 13 math activities (see Table 3) and 14 middle school earth science activities (see Table 4). All of these activities use Group Scribbles and implement one or more pedagogical design patterns summarized in Table 2. Pilot testing of the activities and patterns shown in Tables 2-4 began this spring and will continue through the year.

Table 3. Group Scribbles middle school math activities developed in Year 2.

Math Topic	Activity	Description and Patterns
Fractions	Ordering Fractions	Create fractions (using birthday month as the numerator and birth date as the denominator) and then compare and order fractions with the class. [Info Posing; Organize It]
Order of Operations	Four 4's	Use order of operations to create equalities out of four 4's. [Distributed Problem Solving]
Order of Operations	Bingo	Use order of operations to create equalities using four 4s until a team has a BINGO. [Distributed Problem Solving; Collaborative Game]
Order of Operations	Missing Operators	Use order of operations to create equalities by posting missing operators. [Distributed Problem Solving]
Units	Unit Conversion	Compare weights, capacities, geometric measures, times, and temperatures within and between measurement systems. [Pipeline]
Fractions	Simplifying Fractions	Reduce fractions into simplest form. [Pipeline]
Classification	Classifying Numbers	Use vocabulary words to classify different numbers. [Info Posing; Organize It]
Addition/Subtraction	Climbing the Ladder	Add and subtract integers in order to move their climber up and down a ladder. [Collaborative Game]
Fractions	Representing Fractions	Draw different visual representations of fractions and discuss the different types of representations. [Distributed Problem Solving]
Place Value	Race to the Millionth	Place digits in correct place value order to match the number said orally by the teacher. [Organize It]
Linear Equations	Guess My Function	To introduce the topic of solutions of linear equations, the teacher displays a linear equation along with many ordered pairs. Students identify solutions, try to discover functions given ordered pairs, and discuss differences in functions. [Distributed Problem Solving]
Central Tendency	Measures of Central Tendency	Investigate measures of central tendency with mini bags of Skittles and M&Ms. [Info Posing; Organize It]
Quadrilaterals	Classifying Quadrilaterals	Students classify and create different quadrilaterals based on information about their sides, angles, etc. [Organize It]

Table 4. Group Scribbles middle school earth science activities in development.

IES Investigation	Activity	Description and Patterns
Dynamic Planet, 7	Relating Earth Systems	Students find connections between events associated with Earth's dynamism and the rest of the Earth system. [Concept Mapping]
Dynamic Planet, 2	Waves and Wave Speed	Students discuss and compare data and calculations about wave speed. [Group Data Creation and Comparison]
Dynamic Planet, 6	Pangea	Students record and compare sources of evidence about Earth's moving continents. [Group Data Creation and Comparison]
Rocks and Landforms, 1	Researching Rock Types	Students record, share, and compare observation data related to rocks [Group Data Creation and Comparison]
Rocks and Landforms, 4	Explaining Rock Abrasion	Students draw inferences from their own models and measurements of rocks colliding in water. [Group Data Creation and Comparison]
Rocks and Landforms, 5	Erosional Landforms	Students record, share, and compare observation data related to how moving water can create and change landforms. [Group Data Creation and Comparison]
Dynamic Planet, 1	Mapping Questions to Types of Models	Students share their thinking in small group and large group settings about how you make a model of something you can't see. [Question Posing; Organize It]
Rocks and Landforms, 6	Deposition	Students come up with questions about deposition, identify a question to study, and design an experiment to test their question. [Design and Test]
Dynamic Planet, 4	When Lithospheric Plates Meet	Students investigate what happens at a convergent plate boundary, and link their findings to a world map showing plate movements. [Where On This Image?]
Dynamic Planet, 5	Earthquakes and Volcanos	Students research the location of earthquakes and volcanoes on the Earth, work in small groups to mark up a map showing the location of earthquakes, volcanoes, and plate boundaries, and comment on the patterns they see. [Where On This Image?]
Rocks and Landforms, 2	Locating Places on a Contour Map	Student groups study a topographic map and identify and shade map symbols, features and contour lines. [Where On This Image?]
Rocks and Landforms, 4	Devising Models of Rock Abrasion	Students are given rocks and other materials and charged with designing a model of rock abrasion. [Design and Test]
Rocks and Landforms, 6	Deltas and Floodplains	Students openly share, reflect upon and refine their plans for testing a question about deltas and floodplains. [Design and Test]
Rocks and Landforms, 7	Glacial Erosion and Deposition	Students develop hypotheses (predictions) and reasons for glacier advance, glacier retreat, and glacier standstill, and test. [Predict With Reasons]

Finding 3: Pilot and Classroom Implementations

Math classroom implementations

In both of the math classroom implementations, the teachers frequently improvised by moving between working with the whole class and individual students in reaction to student contributions and to support students or get them back on track during an activity. At the end of class, interviews were conducted with the teacher and with three pairs of students.

The first implementation took place in a 7th grade class of low-performing math students in San Francisco. Each student had their own tablet computer, and the instructor projected her screen to the front of the class so that she could point to areas of the screen and easily see the public board at all times. In this implementation, the instructor progressed through the three activities that she planned for the classroom period more quickly than she expected, finishing early. In the first activity, students were asked to take a number from the board, square it, and put the result back. Figure 1 (left) shows a student contributing content to the classroom board. Some students took squared responses off of the board and argued with other students about who was taking scribbles. In response to this problem, the teacher stopped the activity and asked one student, V, to arrange the scribbles on the board (i.e., she improvised by switching from full class working to one student working.) Student V was very responsive and engaged in the task and talked through it with the teacher and class, asking where certain numbers were and adding ones that were missing as he was arranging them.

In the second, "place value" activity, each student took one digit from the board, the teacher read off a large number, and the students created the number on the board. The group collaboration worked for the first number (students constructed it successfully), although some students were disappointed that their digit wasn't used. For the second number, one student noticed that "there should be a comma" and then made and contributed one after the teacher suggested that he do so. Some students started making their own versions of the number, and the board started to get messy, so the teacher turned on the "show names" features so that she (and the other students) could see which scribbles belonged to which students (i.e., she improvised by removing anonymity to get students back on track). One student commented, "this is hard with other people, we don't know how to work together."

In the final activity, the students each took an operator from the board, the teacher wrote equations on the board with blank spaces where the operators would go, and students were asked to put the operators in the equation to make it true. Most of the students were on task trying to figure it out, but a few were playing with scribbles, writing names on them and putting them up on the board. Other students, like V, said "stop playing!" and removed the off-task scribbles from the board. As a group, they solved 3 equations in about 5 minutes.

In the interviews, all of the students reported that the activities were fun and they'd like to use Group Scribbles again. Two of the student pairs added that it was also challenging because they "don't know how to collaborate." The teacher reported that one of her core goals was to teach her students how to work and learn together. She was pleasantly surprised at how well behaved and engaged they were. For example, two students who she described as "very bright but often do nothing in class" (including student V) got very engaged and even led portions of some activities, and one student "with low math skills" got very engaged. She also liked how Group Scribbles gave her students some privacy: other students didn't see individual's problems until the individual figured it out and posted. Because it was difficult for the students to all collaborate

on one board, she said that next time she might want to create multiple group boards and assign small groups to separate boards instead of having all of the kids interact on one board.

Figure 1. A student contributing content to the classroom board (left) and a math teacher interacting with student contributions via a SmartBoard (right).

The second implementation took place in a 6th grade class of low-performing math students in Menlo Park, CA. Each student had his/her own tablet computer, and the instructor interacted with boards and scribbles directly using a SmartBoard in her classroom. Figure 1 (right) shows the teacher viewing student contributions and interacting with them using her SmartBoard. In this implementation, the teacher had planned to complete up to three different activities, but only completed one activity, partly because the students spent almost half of the class on the warm-up activity, writing their names on scribbles and dragging them to the public board. The teacher found that it was difficult to keep the students on task because they seemed to be easily distracted (e.g., drawing on their private board) and excited about the technology. A couple of times during warmup, the teacher asked students to "put your hands on your head and stylus down" in order to get their attention and to stop them from playing around.

After the warmup activity, the students completed three versions of the "place value" activity, in which each student took one digit from the board, the teacher read off a large number, and the students created the number on the board. Early on, the teacher turned on the "show names" features so that she (and the other students) could see which scribbles belonged to which students (i.e., she improvised by removing anonymity to help keep on track). As with first implementation, most students were on task, but some were removing other student's numbers from the board. At one point, the teacher selected the "freeze" option in Group Scribbles so that students could no longer take or put scribbles on the public board. She told them not to remove other's numbers, and then unfroze the board. The students seemed to not be able to remember the number the teacher read, even when she repeated it several times. They also seemed confused by the negotiating of where to put their number on the board and how to prevent others from taking a scribble or having it move off the public board. The teacher uses the SmartBoard to draw underlines for each digit in the number, which helps by giving the students a clear target for where to put their digits. Because of these difficulties, the first number takes 15 minutes for the class to complete. The teacher then reads off a second number, and the class is able to complete it in about a minute. When one required digit (an 8) is not put on the board; the teacher asks if

any student wasn't able to contribute their number; when one student raises his hand, she asks him to draw an 8 and put it where it belongs. The class does a final (third) number, which takes a little longer because there is more classroom discussion.

In the interviews, the students reported that the activities were fun and they'd like to use Group Scribbles again. They said that some kids were "playing around" too much and "kept moving other people's stuff" so it took a long time, but they "learned teamwork and communication." The students recommended that the software should make it so that other people can't drag your scribbles and make it so that scribbles cannot overlap. The teacher reported that her class didn't get near as far as she thought they would, but that this is the lowest level of math students in the school, and they "just want to play." She thought she could just go over the rules once, but she had to repeat them for every number she read. Next time, she said she would break them up into three small groups with a teaching aid working with each group. She noted that in her school, the students are trained about how to collaborate when they get to 8th grade, so these kids haven't had any such training, and it took them a long time to learn how to collaborate with each other in a whole-class setting.

Thus, a key issue that came up in both implementations was that these (young) students didn't know how to collaborate effectively with each other in a whole-class setting. However, they did improve through the course of the activity with the help of the teacher, who reacted to problems by calling out individual students to take on specific roles and by interacting with the public display to clarify the task (e.g., drawing lines to indicate where numbers should go) and manage the classroom (e.g., by freezing the board or removing anonymity). Group Scribbles may offer an opportunity for students to learn and practice collaboration skills through more continuous use, perhaps in conjunction with more formal training on how to collaborate (e.g., in 8th grade, when such training occurs). For younger students such as those we observed who do not have such training or experience, small-group (rather than whole-class) activities may be a better way to organize Group Scribbles activities, at least initially. Additional controls may also be useful for managing activities with younger students; for example, a switch for the teacher to (temporarily) make it so that students can only move scribbles that they create or own.

Earth Science pilot studies

In our first internal pilot session, which tested the Researching Rock Types activity, students were able to work within an individual board and also respond and interact in public boards that were part of a small group space and a whole-class space. In this way, Group Scribbles supported a range of social structures. A challenge for the teacher was managing the social structures and moving students to and from individual, group, and class level interactions. The representations used on the boards were also critical. For example, the public board had a different representation (a Venn diagram) than did the group boards (which had tables), and aggregating student work from the group boards to the public board didn't work as well as expected because students were unsure how to transfer between these differing representations. Finally, the specificity of instructions was important. Telling students to "describe a rock" on scribbles was too vague; saying "put one word on each scribble" to describe your rock was much more helpful. Figure 2 shows a screenshot from the final classroom board for this activity, where all of the student groups combined their observations about different rock types.

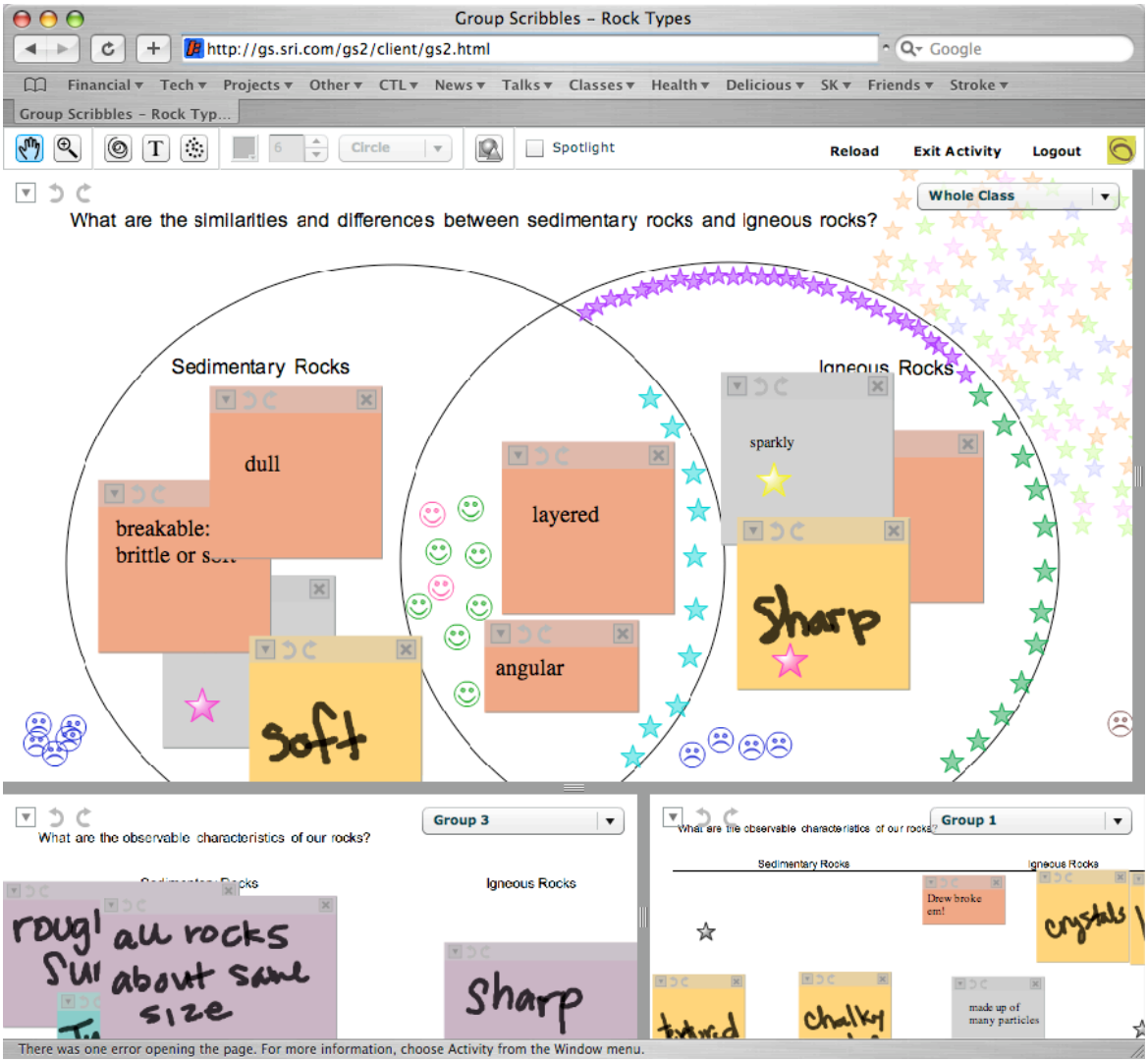

Figure 2. Final classroom board showing aggregated work by different student groups on the different rocks types that they observed and described.

Results of our second internal testing session of two Group Scribbles activities (wave speed and deposition) suggested that the teacher needs a fair level of familiarity with the technology to be able to troubleshoot technical issues that may arise and adjust instruction as needed. Otherwise, the lesson flow and focus can get sidetracked by technical issues. We also found that students can effectively use Group Scribbles while conducting hand-son investigations; however, students need to also have a level of familiarity with Group Scribbles so that the procedural aspects of using the technology do not interfere with the conceptual work. The testing session also raised a question to pursue in later piloting: What situations are best within lessons for students to record work in Group Scribbles? For instance, during a data collection activity, it might work well for students to record and analyze data on paper, then post in Group Scribbles their findings for discussion. One other occasions, it may work best to do all work in the Group Scribbles space. A next step, then, is to begin to articulate those instances in lessons.

All of the activities were revised based upon pilot testing. For example, background images

and instructions for writing and use of board backgrounds were clarified, and materials and instructions for the experimental investigations were also refined. We also determined that the lessons may need to be made more transparent and accessible for teachers by clarifying where and how the technology fits into existing activities (e.g., by adding snapshots of Group Scribbles screens to the lesson plans).