How You Look at It: Multiple Views of a Generative Data Set
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1.0 Introduction
If the topology of classroom activity changes, it drives a need for new ways to assess that activity. Computer supported collaborative learning, by its very nature, changes the topology of classroom interactions. No longer are the interactions bound by verbal rules of communication. Students can all answer the same question at the same time (Roschelle, Penuel, & Abrahamson, 2004a), or collaboratively build a database of knowledge (Scardamalia & Bereiter, 1994), or control a point in a coordinate plane (Stroup, Carmona, & Davis, 2005) or even be an element of force navigating a giant donut through space (Stroup, 2010). Not only is the topology of the interactions changed, but also the classroom artifacts are changed and now include the digital participation of the students. Because those interactions are computer supported it is possible to collect an expansive data set of student artifacts from even a single enactment of one activity in one classroom. These expansive data sets engender a need for new assessment tools.

This commentary paper reports on research by the GenSing (Davis, 2007a) project to create a suite of visualization tools for the assessment and analysis of large datasets created by Generative Activities (Stroup, Ares, Hurford, & Lesh, 2007). Generative Activities as facilitated by a classroom network, can result in a dataset generated by one classroom, in one session, consisting of over 300 expressions (Davis, 2007b). This paper will specifically focus on the creation of tools to make sense of, and reflect on, the array of data created by these activities.

2.0 Overview of Generative Activities
Generative Design, as defined by Stroup, Ares and Hurford 2007, is a way of designing classroom activity to fully utilize the classroom space and leverage diversity. Wherein instructional tasks do not prescribe either the method of reaching the solution nor bound the solution to one correct answer. In answering these questions students generate a set of responses that is then used to explore the topic of instruction.

This paper focuses on generative activities enacted during introductory algebraic instruction at the Secondary 1 level in a Singapore Secondary School. Specifically on a series of activities where students generated expressions equivalent to y=4x, y=2x and y=x-6. The curricular activities were created using the principals of generative design (Stroup et al., 2007), incorporating function-based algebra (Kaput, 1995) and facilitated by the use of a classroom network (Roschelle, Penuel, & Abrahamson, 2004b; Stroup et al., 2002). Research has shown that the generative function-based approach to teaching algebraic concepts has the potential to improve students’ understanding of the structural aspects of introductory algebraic concepts (Stroup et al., 2005).
3.0 Design as a way to help practice and build theory
The first round of data analysis, was guided by the teacher questions:

1. How do we know how the class is doing?
2. How do we know how individual students are doing?
3. How do we know what math is happening?

The data analysis (Davis, 2009), which was guided by the questions above, was not automated in any way. The expressions were evaluated and coded manually and a series of Excel pivot tables was created in an attempt to get a consolidated view of the activity, both at the student and classroom level. This method of formatting the data was not formative assessment friendly. The presentation of statistics drove the reader to a summative use of the data. This data analysis, discussed in detail in Generative Activities: Making Sense of 1098 Functions, Davis 2009, increased understanding of the teacher-generated questions, but also raised additional, more researcher focused, questions.

1. How does students’ work in the public space impact other students?
2. How can teachers use the data?
3. How can things be done to the data to make it useful for teachers?

These new questions drove the need for new data visualization tools.

The data discussed in this paper was collected via the TI Navigator system. A data collection script was created that allowed all of the expressions, and their metadata (e.g. timestamp, student ID), submitted by students to be saved to a spreadsheet. A number of different visualization tools were then created to allow for different views onto the data set. Each view was created to focus on different assessment needs of the varying stakeholders; teachers, researchers, curriculum developers, professional development providers, and funding agencies.

4.0 Explore Representations
In the current GenSing research project, the GenSing Visualizer (Davis & Brady, 2010) was the first tool created. This tool was designed to be a teacher-facing tool to help reflect on individual lessons or a series of activities. The tool allows the teacher to look at an individual, multiple individuals an entire class or multiple classes. These different filters can help the teacher to understand what mathematics is happening in the classroom, if individual students are struggling, and how both classes and individuals progress across a series of activities. The screen capture on the next page shows all of the expressions from the three different activities sorted first by student and then by time. The highlighted expressions are graphed in the right-hand window, color-coded green for matching the target function and red for missing the target function.
One student’s work across three activities is highlighted, from this view two things are quickly readable; 1. the student is most comfortable with additive strategies, and 2. their interest in creating expressions that exhibit the social strategy of many terms (many terms is defined as any expression with four or more terms) (Davis, 2009) increases across the three activities. The statistics at the bottom of the screen show data for the entire class for all three activities, where of the 634 expressions that were submitted, 83 used the social strategy of many terms. While some of the above highlighted student submitted expressions are incorrect, sorting by times shows that for the most part, the incorrect expressions were submitted early in each activity and that by the end of the activity the student was successful in matching the target functions.

By contrast, the highlighted work in the screen shot on the next page shows a student, who across all three activities was only successful in matching the target function when submitting either the target function itself or a provided example. This is not being tracked for punitive reasons but is important data for the classroom teacher to have for assisting the student.
The GenSing Wave Visualizer (Davis & Effendi, 2010b) below, was created using a ripples-in-water metaphor. The Wave Visualizer focuses on patterns of student submissions and the influence of items in the display space on the submissions of other students. In other words, are expressions sent to the display space “contagious”? There is a strongly held belief among researchers and teachers using classroom networks that the group display space is very important and influences student participation and creativity. The Wave Visualizer was created to help illuminate that influence.
In the screen shot on the previous page, all of the expressions submitted over the course of the 4X activity are posted in a scrollable yellow window. To the left and above the yellow window are different representations of the intensity of submissions over time. The brighter white areas are the times when more functions were being submitted. In the example above there was a period of intensity of submissions starting just before the fourth minute and going to the fifth minute, and then another right at the end of the activity. Future research, will tie this visual representation to detailed analysis of classroom video to explain what was happening during these two time periods to find trends that impact student contributions.

One of the features of the GenSing Wave Visualizer is the ability to filter by mathematical strategies (Davis, 2009) (in the example above, student submissions that use rational terms) and to tag a specific submission (in this example 16x/4) and then sort for matching expressions. In the example above we can see that both 16x/4 and 8x/2 were “contagious”.

The final tool to be discussed in this commentary paper is the GenSing Spiral Visualizer (Davis & Effendi, 2010a). This view onto the data is a first attempt to create a visual data representation that facilitates a discussion of creativity. The three images captured from the Spiral View below, are from the same class, across the series of three different activities (y=4x, y=2x and y=x-6). The Spiral View shows the unique functions submitted over the course of an activity arranged in order of time submitted. The first function submitted is at the three o’clock position with subsequent functions going clockwise around the grey circle. The length of each spoke is proportional to the time at which it was submitted and the interior black marks indicate the number of times that exact expression was submitted.

As you look across the three spirals, you can see the growth in number of expression submitted and the complexity of those expressions.
Target function $y = 4x$

Target function $y = 2x$
5.0 Discussion
The views onto the data privilege different aspects of an activity's enactment. The GenSing Wave Visualizer gives views of the data that give a sense of different submission patterns. The GenSing Spiral Visualizer gives a view of the activity's enactment at the classroom level. The GenSing Visualizer allows the user to load multiple class activity files and view either a student or a class for one or multiple activities. Each tool can be used to get both a snapshot of the individual lesson, and to do more in-depth analysis for patterns. An over-time set of data from the same teacher and the same class was intentionally chosen for this paper to show sensitivity to instruction over time. These same tools can be used to compare different teachers' implementations of the same activity and the differences are often striking. But absent the additional detailed analysis of the classroom video tied to the digital data, a comparison of implementations was premature.
Bibliography


