Design Study on Algebra Reform: A GenSing Project

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Abstract: This paper reports on classroom-based research created to design and implement an algebra reform curriculum. This paper focuses on the students' pre-assessment and post-assessment data collected during the second year of a continuing design study. Analysis of gains by section revealed that intensity of student gains did not mirror student stream/band placement. A one-way ANOVA showed that the difference in gains between the groups with different levels of implementation fidelity was significant $F(2,207) = 26.61$, $p \leq 0.05$.

Introduction

This paper reports on classroom-based research created to design and implement an algebra reform curriculum based on the principals of generative design (Stroup, Ares, Hurford, & Lesh, 2007) that incorporates function-based algebra (Kaput, 1995) and is facilitated by the use of a classroom network. 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, Carmona, & Davis, 2005) and that new classroom-networked technologies provide opportunities to increase student participation and engagement with the topics of instruction (Davis, 2002).

Methods

Research Design - The multi-tiered design study (Kelly, Lesh, & Baek, 2008) focused on students' developing understanding of function-based algebra via Generative Activities in a networked classroom and the teachers' pedagogical practices needed to foster these activities. This paper focuses on the students' pre-assessment and post-assessment data collected during the second year of a continuing design study into Generative Activities in Singapore (GenSing).

Participants - The data for this study was collected at an upper-performing secondary school in Singapore. The participants encompassed all of the 2008 school year, Secondary 1 (12 to 13-year-olds) express-track students (n = 239) at the research site. Data was collected from six sections (classes) and each section ranged from 39-41 students. The academic year for the 2008 Secondary 1 students began in January, ending in October, and was divided into four terms. Each Secondary 1 express-track mathematics section was taught by a different teacher and each teacher remained with their assigned section throughout the school year. This provided the opportunity to study six separate teachers and the integrity of pedagogical implementation.

Intervention - The Secondary 1 mathematics scheme of work (scope and sequence) was reorganized to gather all of the algebraic topics covered across the year into two cohesive groupings, one lasting eight weeks and one lasting four weeks. In accordance with generative design principles, the questions and the opportunity for student input are structured to allow for students' individual creativity and exploration of the mathematical topic. The intervention teachers observed model teachings of the activities in their own classrooms with their students, experienced the activities as students in a series of department meetings, and participated in a 2-day workshop. During the 2008 intervention each activity was previewed the week prior to its implementation with the teachers during a planning period. During the activity-preview questioning strategies, possible student responses and ways to use the technology to help foster class interactions were discussed.

Data - For the 2008 implementation, a pre-assessment and post-assessment was created. The research project is iteratively designing a 20-item, algebra assessment to not only assess students' computational ability to manipulate variables but to also evaluate students' conceptual understanding of algebraic topics. The data reported on in this paper reflects the first iteration of the pre-/post-assessment.

Results

For the purposes of analysis, the students' responses to individual items on the pre-assessment and the post-assessment were divided into quantitative and qualitative data segments. The quantitative and qualitative data were analyzed using different methods and this paper will focus on the quantifiable items. For the 28 quantitative items, a paired samples t-test (Table 1) showed a significant difference between pre-assessment and post-assessment results ($t = 21.356$, $df = 207$, $p \leq 0.05$).

Table 1: Paired samples statistics.

		Mean	N	Std. Dev.	Std. Error Mean
Pair 1	Post	18.45	210	3.472	.240
	Pre	13.09	210	2.808	.194

Comparison of Pre-Test to Post-Test Gains by Sections

The gains were then calculated for each section of the Secondary 1 students to investigate possible classroom effects, and statistically significant differences were found between the sections. We argue that the difference between gains in sections is the result of the integrity of intervention implementation. One section (n=37) had Level 1 implementation integrity with a mean raw gain of 8.22; three sections (n=107) had Level 2 with a mean raw gain of 5.22; and 2 sections (n=66) were at Level 3 with a mean raw gain of 3.83.

To assess if the gains were statistically different across the three levels of implementation, an ANOVA test was carried out. Hake's Gain score (Table 2) was calculated for each student and used as the measure of gain for the ANOVA test. Hake's Gain was chosen to adjust for the "ceiling effect" where students who scored high on the pre-test had less room for gain compared to students who scored lower on the pre-test (and therefore, could potentially inflate the gain scores of students who scored lower on the pre-test). The Level 1 implementation group had a mean Hake's Gain score of 0.57, meaning that on average, students from this group made a 57% gain over what was possible, based on their pre-test score, the means for implementation Level 2 was 0.33 and Level 3 was 0.26.

Table 2: Hake's Gain.

	N	Mean	Std. Dev.	Std. Error	Minimum	Maximum
Level 1	37	.5667	.23273	.03826	.07	.86
Level 2	107	.3347	.21249	.02054	-.50	.76
Level 3	66	.2562	.19135	.02355	-.25	.77
Total	210	.3509	.23416	.01616	-.50	.86

A one-way ANOVA (Table 3) showed that the difference in gains between the groups with different levels of implementation was significant $F(2,207) = 26.61$, $p \leq 0.05$. The effect size was medium ($\eta = 0.45$). Results indicated that integrity of implementation had a medium impact on gain.

References

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