

# Technology Use in Ability-Grouped High School Mathematics Classrooms

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## Abstract

This paper investigates the differences in types of technology and frequency of use in Pre-AP, regular, and trailer ability groups of high school Algebra and Geometry courses. Fifty-one high school mathematics teachers from eight schools completed a set of surveys. Additionally, two teachers were interviewed and observed. Data indicated that regular classes implemented the most types of technology, but Pre-AP and trailer classes had higher individual and overall frequencies for each type of technology used. Overall, teachers of all groups favored calculator use. Data also suggested the frequent technology use in trailer courses may be due to teachers' desires to provide new experiences to previously unsuccessful students.

## Introduction

Educators have long looked for ways to improve the education system. Reforms such as the excellence reform and the restructuring reform were designed to improve education for all students, but met with contention and were abandoned. The standards reform aimed to improve education for all, but also provided a basis for accountability and platform for future reforms; something other reforms did not possess. This may be why this particular reform movement has lasted over 12 years and has become the basis for content standards, such as the National Council of Teachers of Mathematics' [NCTM] *Principles and Standards for School Mathematics*, and technology standards such as the International Society for Technology in Education's [ISTE] *National Educational Technology Standards for Students*. Documents such as these emphasize the use of technology in the classroom because it is a present day necessity and a means of achieving the goals set forth by reforms. Educators understand that technology's benefits, especially in the mathematics classroom, provide students with opportunities to visualize concepts, and spend less time in complex computational tasks and more time for inquiry; they also see its potential to teach students with special needs. Learning technology in school helps students perform in a society saturated with opportunities for problem solving, communicating, and analyzing. Therefore, "it is in the best interest of both today's young people and the nation as a whole that *all* students have an opportunity to master the elements of technology they will need to have a productive future". But not all students have had access to technology. In Sutton's (1991) literature review of access studies from the 1980s, she reported that computer use in education maintained some of the inequities already existing in society.

These studies reported that teachers were using technology to help students with special needs, but focused more on high ability students who were spending more time on the computers and doing more critical thinking activities than lower ability students, who were using computers for drill and practice activities . Access to technology was now another area that confirmed what had been debated since the inception of ability grouping in the 1920's: high ability groups are favored at the expense of low ability groups . Yet, regardless of ability, students must still meet the same standards and prepare for the same future; a future where technology has become commonplace. It is the hope of researchers that this can be accomplished without further widening the gap between ability groups .

## Problem

Since the 1980's studies on computer use among ability grouped students, there has been relatively little new information specifically focusing on technology and possible differences in its use in groups determined by ability. This study reexamines possible differences in the use of a variety of instructional technologies among the ability groups by investigating the research question: Are there differences in the type, and the frequency of technology used in Pre-AP, regular and trailer high school Algebra 1, Geometry and Algebra 2 classes?

## Methodology

The data reported here came from a study investigating various aspects of technology use in ability grouped classrooms. Data consisted of surveys, interviews and classroom observations, and was collected for three specific ability groups: Pre-Advanced Placement [Pre-AP] classes that move at a faster pace, and study subject matter in a more complex and in-depth way; trailer classes that repeat the material from the previous semester for students who failed; and regular classes that are neither Pre-AP nor trailer. These ability groups were examined for high school Algebra 1, Geometry, and Algebra 2 classes.

## Instruments

Surveys were distributed to Mathematics Department Chairs at a meeting held in early May 2004; and the individual department chairs then distributed them to their math faculty. Teachers were given two weeks to complete the surveys. The survey was 17-pages long and had 26 questions. These questions asked teachers about staff development, interpretation of rules and requirements, benefits and disadvantages of technology use, obstacles and assistance in technology use, and types and methods of technology previously implemented. Seventeen of the technology specific questions were open-ended, one was a 19-part Likert scale question, and one question contained a technology chart. Seven open-ended questions addressed the teachers' perception of the characteristics of the Algebra 1, Geometry, and Algebra 2 classes they were teaching at the time.

Teachers' responses to the technology chart (see Appendix) produced most of the data used in this paper. The chart is composed of eight columns representing the teacher's individual class periods (courses corresponding to the periods were identified by the teachers' responses

on a separate survey question), and 23 types of technology on the rows. The 23 types of technology listed included 35mm cameras, digital cameras, videotapes, VCRs, TVs, video recorders, LCD panels, In Focus machines, Smart Boards, scientific calculators, graphing calculators, Computer Algebra System [CAS] calculators, Calculator-Based Laboratories [CBL], Calculator-Based Rangers (CBR), PCs, Macs, Internet, e-mail, word processors, databases, spreadsheets, Geometer's Sketchpad [GSP], and Carnegie Tutor. This technology list includes specific examples of technology taken from a list of technology categories used by the Roanoke Valley Governor's School in designing math labs that met with national mathematics standards. Teachers were asked to fill out this chart by stating the number of times each piece was used in a semester. They were also given the choice to add any equipment or software not listed on the chart.

## Participants

Even though, one hundred seventy-six surveys were handed out at the initial department chair meeting, only fifty-three surveys were returned after the two-week period. Two were omitted due to unsigned consent forms. Thirteen of these teachers taught Pre-AP classes; fifty-five taught regular and sixteen taught trailer classes. Subject anonymity was kept by coding the districts with numbers (1 and 2), the schools with letters (A-H), and the teachers with another number. District anonymity is retained throughout this paper, including references and citations. For participation eligibility, no bias was placed on teacher experience, gender, or race. Similarly, no high school was refused participation based on the race, gender, or socioeconomic background of their student population. Yet, since these schools are located in a border community their characteristics are very similar. Six of the eight schools have over 50% economically-disadvantaged students and all eight schools have a Hispanic population that exceeds, in average, 60%. Regarding teacher population, four schools have women as the majority percentage and five schools list Hispanic as the majority race of their teachers.

Classroom observations and follow-up interviews were conducted with two teachers who volunteered. Of the observed teachers, one was from School C in District 2, and the other was from School B in District 1. Teacher 2C-2 was a white male with 13 years of teaching experience. He was observed during his Pre-AP and regular Algebra 2 classes. Teacher 1B-5 was a white female teacher with 17 years of experience. She was observed in her Pre-AP and trailer Algebra 1 classes. Observation dates were selected prior to the researcher's knowledge of the lesson for that day, except for knowing that no tests or quizzes were scheduled. The teacher from School C was observed four times, twice per class; while the teacher from School B was observed six times, three times per class. Differences in number of observations were due to differences in teacher availability. Interviews were structured around already submitted individual survey responses and classroom observations.

## Analysis

In determining the frequency of technology use, only those surveys where teachers gave a number (some teachers responded with a checkmark) of uses for the semester were considered. Total number of days of use for each piece of technology was calculated by summing the responses given by the teachers from the subject and ability group being examined. Ninety was used as the maximum number of days in a semester since there were ninety school days in the particular semester. If teachers reported "everyday" or a number

larger than 90, then 90 was used in the evaluation. The result from the summation was divided by the total number of teachers for the subject or ability group being examined to obtain the frequency (averages) of use for each technology.

Averages for overall technology use were found by summing the averages for all pieces of technology and then dividing by the total number of technologies reported by the subject and ability group being examined. For example, suppose that Pre-AP Geometry teachers used the computers for an average of 18 days, the calculators for an average of 45 days, the digital camera for two days, and the remaining 28 types of technology for zero days. The sum, 65 days, would then be divided by three (number of technologies used) in order to get the reported average for the overall technology use, 21.7 days.

## Results

### Algebra 1

For Algebra 1, two Pre-AP teachers, 13 regular teachers, and nine trailer teachers' charts are used in analysis. Table 1 reveals that teachers of regular courses used the most types of technology, with 16. Pre-AP classes used 2 different types and trailer classes used 9 types. However, nine of 16 pieces of technology used in the classes were, on average, used less than one day. For trailer Algebra 1, only two of the nine technologies were used less than one day.

Table 1 also indicates that the most used piece of technology for all ability groups of Algebra 1 was the graphing calculator. Of the three ability groups, Pre-AP classes had the highest use of graphing calculators, which were used 90 days of the semester. Regular and trailer classes used the graphing calculator for an average of 61.07 and 59.33 days, respectively. For Pre-AP Algebra 1, the second most used piece of technology was the only other type used, the Online Academy, with only seven and a half days of the 90 day semester. For regular and trailer Algebra 1, the second most used piece of technology was the scientific calculator, with 28.46 and 30 days, respectively.

Table 1

#### **Frequency for each type of technology used (in days) for Algebra 1.**

Type of Technology	Algebra 1		
	Pre-AP	Regular	Trailer
35mm Camera			
Digital Camera			
Videotape		< 1	
VCR		< 1	
TV		< 1	
Video Recorders			

LCD Panel		14.38	12
InFocus Machine		< 1	< 1
SMART Board			< 1
Scientific Calculators		28.46	30
Graphing Calculators	90	61.07	59.33
CAS Calculators			
CBL		7.31	14
CBR		< 1	
PCs		12.62	21
Macs			4.44
Internet		< 1	
Email		< 1	
Word Processors		< 1	
Database			
Spreadsheets		< 1	
GSP			
Carnegie Tutor		11.85	25.44
Other: Overhead		6.92	
Other: Online Academy	7.5		
Other: Fathom Dynamic Statistics			
Other: Sleek IT!			
Other: Online Glencoe			
Other: Java			
Other: Scanner			
Other: Photo Lab			
Total Number of Types Used	2	16	9

## Geometry

For Geometry, six Pre-AP teachers, 22 regular teachers, and one trailer teacher turned in technology charts with numerical values. Table 2 indicates that the 16 types of technology used in the regular courses were the highest number of types used by any Geometry ability group; Pre-AP classes only used 13 types and trailer classes used four types. For Pre-AP Geometry classes, four of the 13 types of technology were used, on average, less than one day during the semester. For regular Geometry classes, half of the total types used were used, on average, less than one day a semester. Trailer Geometry courses averaged more than one day use on all four pieces introduced.

Table 2

**Frequency for each type of technology used (in days) for Geometry.**

Type of Technology Use	Geometry		
	Pre-AP	Regular	Trailer
35mm Camera			
Digital Camera			
Videotape		< 1	
VCR		< 1	
TV		< 1	
Video Recorders			
LCD Panel	< 1	13.09	
InFocus Machine	1	1.18	
SMART Board	< 1	< 1	
Scientific Calculators	18	17.27	
Graphing Calculators	73.33	62.73	50
CAS Calculators			
CBL	< 1	2.27	50
CBR			
PCs	12.33	2.45	
Macs			
Internet	1.67	< 1	
Email		< 1	
Word Processors	1.17		
Database			
Spreadsheet	< 1		
GSP	7.67	4	10
Carnegie Tutor	3.17	2.68	50
Other: Overhead		< 1	
Other: Online Academy			
Other: Fathom Dynamic Statistics			
Other: Sleek IT!	1.5	< 1	
Other Online Glencoe			
Other: Java			
Other: Scanner			

Other: Photo Lab

Total Number of Types Used	13	16	4
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Table 2 also shows that for all three ability groups of Geometry, the graphing calculator was again the most used piece of technology. Pre-AP Geometry students used the graphing calculator for the most number of days, 73, regular classes used it 62.73 days, and trailer classes spent 50 days working with the graphing calculators. However, for trailer Geometry, graphing calculators tied with the CBL and the Carnegie Tutor for most days used. These high values are due to the fact that only one teacher's responses could be considered for frequency since the other two trailer Geometry teachers did not give exact values. Pre-AP and regular sections of Geometry both use the scientific calculators second most often (18 and 17.27 days respectively). The trailer Geometry courses used only four pieces of technology throughout the spring semester. Three of them had the same average amount of usage (50 days); the fourth piece of technology, the Geometer's Sketchpad, was used 10 days of the semester.

## Algebra 2

For Algebra 2, four Pre-AP teachers, 15 regular teachers, and two trailer teachers turned in technology charts with their surveys. Table 3 shows that students in regular classes were exposed to 17 types of technology, Pre-AP classes used 12 types and trailer classes used two types. For regular Algebra 2, 12 of the 17 types of technology were used an average of less than one day for the semester. Trailer Algebra 2 classes used both types well over one day a semester. Pre-AP classes used five types less than one day per semester. The high averages for trailer classes are likely due to the few surveys returned from trailer Algebra 2 teachers.

Table 3 indicates that Algebra 2 teachers of all ability groups used the graphing calculator more than any other piece of technology. Pre-AP Algebra 2 students have the

Table 3

### **Frequency for each type of technology used (in days) for Algebra 2.**

Type of Technology	Algebra 2		
	Pre-AP	Regular	Trailer
35mm Camera			
Digital Camera		< 1	
Videotape		< 1	
VCR	< 1	< 1	
TV	1.25	< 1	
Video Recorders			
LCD Panel	21.25	4.87	
InFocus Machine	1.25	< 1	

## SMART Board

Scientific Calculators	22.5	30.8	45
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Graphing Calculators	62.5	60.67	45
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## CAS Calculators

CBL	< 1	< 1	
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CBR	< 1	< 1	
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PCs	5	1.6	
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## Macs

Internet	< 1	< 1	
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Email		< 1	
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Word Processors	< 1	< 1	
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## Database

## Spreadsheets

## GSP

Carnegie Tutor	4	1.2	
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Other: Overhead		< 1	
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Other: Online Academy			
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Other: Fathom Dynamic Statistics		< 1	
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Other: Sleek IT!			
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Other: Online Glencoe			
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Other: Java			
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Other: Scanner			
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Other: Photo Lab			
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Total Number of Types Used	12	17	2
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highest use of the graphing calculators with an average of 62.5 days. Regular and trailer classes used the graphing calculator for 62.73 and 45 days, respectively. The piece of technology with the second highest average was the scientific calculator. Pre-AP Algebra 2 classes used it for 22.5 days, regular teachers for an average of 30.8 days, and trailer classes for 45 days of the semester.

## Overall Technology Use

Table 4 shows the averages for overall technology use. These averages indicate that regular courses, regardless of subject, had the lowest overall averages of overall technology use



despite having the highest number of technologies used. In Geometry and Algebra 2, trailer courses had the lowest number for types of technologies used, but had the highest average for overall technology use. This pattern also occurred in Algebra 1, although Pre-AP courses had the fewest types of technology used and the highest overall average.

Table 4

**Frequency of overall technology use (in days) for each ability group during the Spring 2004 semester.**

Frequency of Technology Used	Pre-AP	Regular	Trailer
Algebra 1	24.38	9.07	18.53
Geometry	9.35	6.73	40
Algebra 2	10	6	45

## DISCUSSION

Examining the types of technology used in each of these classes without considering the frequency shows students in regular courses consistently had access to the highest number of different types of technology in the classroom. However, the high exposure to technology gave no indication to how often each of the technologies was being used throughout the semester. For students enrolled in regular courses, the frequency of overall technology use was low. Similarly, over half of the individual technologies reported by regular-course teachers of any subject were used, on average, less than one day of the semester.

Regular classes did show consistency in their use of the graphing calculator and also in the high frequency of its use. In fact, the graphing calculator was the most frequently used piece of technology for all subjects and ability groups, but was most used by the Pre-AP class of each subject. On a separate survey question when asked to list the types of technology that can be used in the math classroom, approximately 98% of the teachers responded with “graphing calculators.” In addition, on a Likert scale statement, 62.7% agreed that in a math classroom, technology mainly refers to calculators. Teachers may have focused so much on the calculators because the district curriculums and state requirements consistently mention the graphing calculators by name while projectors, cameras, software, and other hardware are lumped together under the category “other technology”. However, teachers are ultimately the ones who choose what or whether technology will be implemented. For example, the use of CAS calculators is encouraged by one district in Geometry lessons, yet, no Geometry teacher – in fact, none of the 51 teachers surveyed – reported using this type of calculator during the semester. The low use of the CAS calculators and the high use of the graphing calculators may also be due to the availability of such calculators.

Pre-AP classes consistently had the highest frequency of graphing calculator use, but this does not signify that all technologies or any piece in particular, is always used more frequently in Pre-AP classes. One piece of technology that was used most often by teachers of trailer courses (in most cases) was the Carnegie Tutor computer program. This program simulates student thinking and responds to their individual problem solving abilities by providing feedback and assessing student work, and has been shown to significantly increase student confidence and success in mathematics. Perhaps this is why the data showed such

high use for this program in trailer courses; and it was because of the high use of the few types of technologies, such as the Carnegie Tutor, used in trailer classes that the overall use of technology was often higher than (or close to, in the case of Algebra 1) the use in Pre-AP and regular courses.

Teachers indicated in their interviews that all students, regardless of ability group, should be exposed to technology so that they can all have the same experiences, especially with the graphing calculators that can be used for the standardized state exams. However, surveys and interviews suggest that teachers see more benefits for technology use with students who are having difficulty understanding mathematics concepts. For instance, Teacher 2C-1 stated in his interview that technology helps students understand concepts without falling behind due to an inability to perform rote operations or graph by hand.

## Conclusion

In summary, the data from the surveys, observations and interviews show that differences in technology types used and frequency of use do exist between Pre-AP, regular, and trailer high school math courses regardless of subject or ability groups. However, the data also shows that no one ability group was consistently favored in all aspects of investigation. Regular classes had consistently high numbers of different technologies used, and low frequency of use for each type; while Pre-AP and trailer classes faced low numbers of technologies, and high frequency of use. Although the numbers are different for the ability groups, teachers seem most consistent toward using graphing calculators, with an additional focus on Carnegie Tutor use in trailer courses. The high frequency of overall technology use in the trailer courses lends to the idea that perhaps schools are responding to different learning styles by providing trailer students more opportunities to learn mathematics in different ways. This contradicts the 1980s research which showed that teachers' focused more on higher ability groups, in this case the Pre-AP classes (Becker & Sterling, 1987; Kozma & Croninger, 1992). However, more research is needed to confirm that the new focus on lower ability groups, in this case the trailer classes, is actually due to a desire to provide new learning experiences for students to help close any achievement gaps. If this is the case, some of the differences that exist between types of technology used and the frequency of technology used may not necessarily be bad.

The results of this study offer suggestions for current practice, although no direct course of action can be established for administrators and teachers working in the field without first examining their educational goals. Districts whose goals include equal technology exposure in their math classes or high use of technology in all classes can focus on specific ability groups to improve technology use in the appropriate manner.

The results of the study also present opportunities for more research on the differences in ability group use of technology in high school math classes. The high frequency of overall technology use in the trailer courses appears to be aimed at providing equity in education and understanding. However, more research is needed in order to study student comprehension, examine grades, and follow student progress to see if frequent technology implementation in trailer courses provides the understanding students lack. To strengthen this argument, more research should also be done on how technology is being implemented in the lessons and whether these uses differ by subject and ability group.



