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Interactive Whiteboards and Student Achievement

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Abstract:
This study explored the effects of teachers' use of interactive whiteboards on students' reading/language arts and mathematics performance. Reading/language arts and mathematics achievement test scores of all students in the third through eighth grades in a small urban school district in northern Ohio were compared between students whose teachers used interactive whiteboards for instruction and those whose teachers did not. A statistically significant but not meaningful positive main effect of whiteboard use on mathematics achievement was found. A statistically significant main effect on reading achievement was not found, although the reading/language arts scores of students whose teachers used whiteboards were slightly higher than those of students whose teachers did not use them. In addition, statistically significant and meaningful interactions between whiteboard use and grade levels were found, leading to a more careful look at differences in the ways teachers employed whiteboards in their instruction. A within-group comparison of such usage between teachers whose students scored above the mean on standardized tests and those whose students scored at or below the mean revealed that teachers of high-scoring students used interactive whiteboards more frequently and in more creative and constructivist ways than did teachers whose students performed at or below the mean. The results suggest that the use of interactive whiteboards can enhance student learning of mathematics and reading/language arts when teachers use them in a manner that takes advantage of their unique capabilities.

Keywords:
Instructional technology, interactive whiteboards, student achievement, mathematics, reading/language arts

INTRODUCTION

Interactive whiteboards are a relatively new instructional technology that is being used in many schools as a replacement for the traditional chalk and blackboard. Many educators see these electronic boards as a versatile digital tool that can help them in increasing student achievement levels. The research reported on in this chapter takes a look at a small city school district in Ohio (United States) that has invested heavily in interactive whiteboards in the hope that their integration in its classrooms will improve student scores on the mandatory state achievement tests. More specifically, the objective of this study was to explore the effects of teachers' use of interactive whiteboards on student performance in mathematics and reading/language arts.

BACKGROUND

Current theories of learning emphasize the importance of actively engaging children in the learning process (Bransford, Brown, & Cocking, 1999), and a variety of digital technologies has been introduced

in schools to support active engagement in learning (see e.g. Swan et al., 2007; van 't Hooft & Swan, 2007). One recently introduced technology is the interactive whiteboard. Interactive whiteboards allow teachers and students to interact with content projected from a computer screen onto a whiteboard surface. Virtually anything that can be done on a computer can be done on an interactive whiteboard. The advantage of an interactive whiteboard is that the interaction with the digital content involves manipulation of information with fingers and pens, making learning with an interactive whiteboard more active, kinesthetic, and engaging. In addition, drawing, marking, and highlighting of any computer-based output is supported; a whole class can follow all such interactions; and lessons (including audio) can be saved and replayed at a later time.

Initial research on the use of interactive whiteboards in both K-12 and higher education, albeit still fairly exploratory, has been promising. Studies have documented that both teachers and students like the technology (Beeland, 2002; Hall & Higgins, 2005; Kennewell & Morgan, 2003; Smith, Higgins, Wall, & Miller, 2005), and that students are more engaged and motivated to learn when whiteboards are employed (Beeland, 2002; LeDuff, 2004; Miller, Glover, & Averis, 2004, 2005; Painter, Whiting, & Wolters, 2005; Smith, Hardman & Higgins, 2006). Moreover, several research studies have noted that the use of whiteboards shifts instruction from presentation to interaction, and moves students' focus away from teachers and onto content, making interactive whiteboard lessons more student-centered than traditional ones (Cuthell, 2005; Miller, Glover & Averis, 2003, 2004; Painter, Whiting, & Wolters, 2005).

Additionally, there is some data-based evidence that the use of interactive whiteboards can increase student achievement. Zittle (2004), for example, explored the effects of whiteboard lessons on the geometry learning of Native American elementary students by comparing pre- to post-test gains of 53 students whose teachers used interactive whiteboards with 39 students whose teachers did not. He found statistically significant differences in gain scores between the interactive whiteboard group (average gain score of 20.76) and the control group (average gain score of 11.48). Similarly, Dhindsa & Emran (2006) compared pre- to post-test gains between college classes that were taught six organic chemistry lessons, either with or without interactive whiteboards. Here too, the authors found statistically significant differences in gain scores between students taught with interactive whiteboards, averaging a mean effect size of 2.68 and the control group, averaging a mean effect size of 2.16.

Two large-scale investigations of the effects of the use of interactive whiteboards on teaching and learning undertaken in the United Kingdom are particularly relevant to the research reported in this chapter. In the *Embedding ICT in the Literacy and Numeracy Strategies* pilot project (Higgins et al, 2005), whiteboards were installed in year 5 and 6 classrooms in 12-15 schools in each of six Local Education Authorities (LEAs). Reporting positive teacher and student responses to the use of interactive whiteboards, this two year study also investigated the effects of whiteboard use on student performance by comparing the mean progress on national tests between students in whiteboard and non-whiteboard schools in the same districts. Findings from the first year of the study show a slight positive advantage for students using interactive whiteboards for learning (ES = .09), but in the second year of the study this trend was reversed (ES = -.10). In the Primary Schools Whiteboard Expansion project, interactive whiteboards were installed in 172 classrooms in 97 primary schools in 20 LEAs. Researchers from the Centre for ICT, Pedagogy and Learning at Manchester Metropolitan University used multi-level modeling to compare the achievements of students learning with whiteboards with students learning without them. Findings showed significant gains in mathematics achievement for high and middle achieving students, but no gains for low achieving students. Findings for science and English language arts were mixed.

The promise of interactive whiteboards as a technology that has the potential to increase student achievement has led many US schools and districts to similarly purchase and install them in K-12 classrooms in the hope that their use will improve student scores on standardized tests. In this study we

report on research examining the impact of one such district-wide implementation. Specifically, the research questions asked were:

- Do students whose teachers use interactive whiteboards to support instruction perform better on standardized tests of mathematics and reading/language arts than those who do not?

- Among classes where interactive whiteboards are used, are there differences in the ways in which teachers use whiteboards between classes whose average test scores are above grade level means and those whose aren't?

SUBJECTS AND SETTING

The research study reported in this chapter took place in a small city school district in northern Ohio (~7,500 students, K-12), which is in Academic Watch under the State of Ohio's accountability system[1]. One-third of the school district's student population are minorities, with the largest number (21%) being African-American. Eight percent of the district's students live below the poverty line. The research was undertaken as part of a larger evaluation of interactive whiteboard use in the district. Because Ohio Achievement Tests (OAT) are given in grades three through eight, the results provided here come from a comparison of OAT scores between students in those grades whose teachers used interactive whiteboards in mathematics and reading/language arts instruction, and students in those same grades whose teachers did not use them. In all, the study involved over 3,000 students enrolled in 11 elementary schools, 3 junior high schools, and 1 alternative school. More specific demographics are provided in Table 1.

Table 1: Demographic Data for Students Participating in the Smartboard Study

Mathematics (n=1392)			**Reading/Language Arts (n=1352)**	
Gender			Gender	
Female	1573		Female	1558
Male	1619		Male	1594
Grade Level			Grade Level	
3	510		3	454
4	519		4	524
5	560		5	565
6	565		6	567
7	521		7	511
8	517		8	531
Smartboard			Smartboard	
Yes	1379		Yes	1466
No	1813		No	1686

Every school in the district was participating in the interactive whiteboard program at the time of the study, although it was implemented first in a few schools and then rolled out across the district. Teachers who received whiteboards were selected by school principals through a variety of methods ranging from

voluntary participation and arm twisting to selection by administrators, although implementation across all grade levels was required. All teachers who received whiteboards had to participate in initial teacher professional development and monthly Saturday meetings throughout the first year they had the boards.

A total of 72 out of 79 teachers in grades 3-8 who had whiteboards in their classroom participated in the research, including 15 male (20.8%) and 57 female (79.2%) teachers. More specific demographics are provided in Table 2. Their teaching approaches ranged from teacher-centered to student-centered.

Table 2: Demographic Data for Teachers Participating in the Smartboard Study

Grade Level	Number of Male Teachers	Number of Female Teachers
3	1	9
4	2	10
5	1	8
6	2	7
7	5	10
8	3	11
6-8	1	1
7-8	0	1
Total	15	57

DATA SOURCES AND ANALYSIS

Data sources for the research included the mathematics and reading/language arts scores of all third through eighth grade students in the district on the Ohio Achievement Test (OAT) for the 2006-2007 school year, as obtained from district administrators. The district also provided demographic information, including students' schools, teachers, grade level, gender, race/ethnicity, and IEP status. In order to determine the relationship between interactive whiteboard use and student achievement in mathematics and reading/language arts, the OAT scores of students whose teachers used interactive whiteboards in mathematics and reading/language arts instruction were compared with the scores of students whose teachers did not use them, using analysis of variance (ANOVA). Post-hoc T-tests were run separately for each grade level to look for statistically significant differences at individual grade levels.

In addition, data concerning teachers' use of interactive whiteboards was obtained through an online survey completed weekly by teachers using whiteboards in their classes, from February 2007 through April 2007. Data collected via these self-reports included the frequency of interactive whiteboard use in mathematics, in reading/language arts, and for classroom management. Respondents were also asked to note effective or otherwise interesting uses made of interactive whiteboards during the previous week in mathematics instruction, in reading/language arts instruction, or for classroom management. Out of a total of 142 teachers using interactive whiteboards in the entire district a total of 109 teachers responded (77% response rate), with weekly responses varying between 30 and 67. For grades 3 through 8 only, a total of 79 teachers used whiteboards and 72 responded (91% response rate). While not all teachers replied each week, a majority of the teachers responded at least once a month.

Researchers also conducted two focus groups with participating teachers to obtain additional data regarding instructional use of the interactive whiteboards and teachers' perceptions regarding the impact of this technology on teaching and learning. The focus groups were conducted in conjunction with

Saturday teacher meetings in the district and provided data that was triangulated with the survey responses.

To explore potentially more effective uses of whiteboards, whiteboard teachers whose students scored above overall district means on standardized tests of mathematics and/or reading/language arts were identified. These included 19 teachers whose students' scores were higher than the general mean in reading/language arts and 17 teachers whose students' scores were higher than the overall mean in mathematics. Self-report survey data for these teachers were descriptively compared with self-report data from teachers who used interactive whiteboards but whose students scored at or below the district mean in reading/language arts and/or mathematics. First, weekly frequency of whiteboard use was averaged for each teacher across the ten-week reporting period and then average use was compared between teachers with high-achieving students and all other teachers, in three categories – frequency of use for mathematics instruction, frequency of use for reading/language arts instruction, and frequency of use for classroom management. In addition, teachers' comments concerning whiteboard usage in each category were qualitatively analyzed for themes and trends and similarly compared between high achieving and average and/or below average classes.

RESULTS

In the sections that follow, findings from statistical comparisons of standardized test scores between students whose teachers employed interactive whiteboards and those whose teachers did not are summarized -- first in terms of mathematics performance and then for reading performance. Finally, comparisons in usage between high achieving whiteboard classes and other classes using the technology are summarized.

Between-Group Comparisons of Achievement Test Scores

Mathematics Achievement

A total of 1379 students in the data set were enrolled in the classes of the 31 teachers who used interactive whiteboards for mathematics instruction in grades three through eight, while 1813 students were enrolled in the classes of the 43 teachers who did not use interactive whiteboards in those grades. When comparing students whose teachers used interactive whiteboards for mathematics instruction to those whose teachers did not, the interactive whiteboard group performed slightly better (M = 415.81) on the Ohio Achievement Mathematics Tests than the group that did not use interactive whiteboards (M = 414.63) across all grades. This difference was statistically significant, F (1, 3168) = 5.591, p = .018, d= .08 Additionally, there was a statistically significant interaction between interactive whiteboard use and grade, F (5, 3168) = 2.925, p = .012. As shown in Figure 1, students in mathematics classes with interactive whiteboards outperformed students in classes without them in all grades except grade 6. T-tests run separately for each grade level showed statistically significant differences for grades 4 and 5 only, t(516) = 2.987, p = .003, d = .26, and t(558) = 2.879, p = .004, d = .25 respectively.

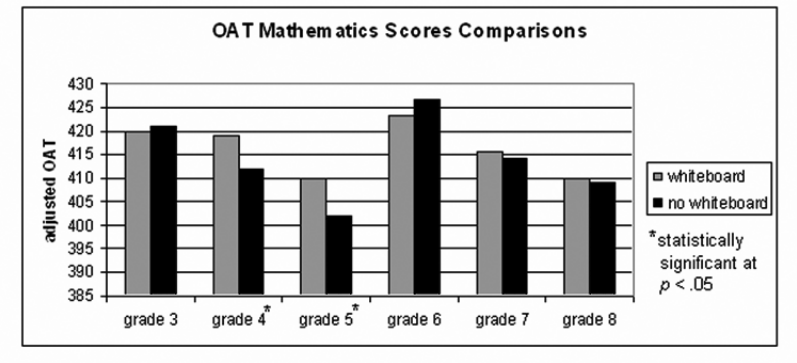

Figure 1. Comparison of Standardized Mathematics Scores across Grade Levels by Whiteboard Usage

No interactions between gender and interactive whiteboard use were found at particular grade levels.

Reading Achievement

A total of 1466 students in the data set were enrolled in the classes of the 35 teachers who used interactive whiteboards for reading/language arts instruction in grades three through eight, while 1686 students were enrolled in the classes of the 45 teachers who did not use interactive whiteboards in those grades. When comparing students whose teachers used interactive whiteboards for reading instruction to those whose teachers did not, the interactive whiteboard group performed slightly better (M = 416.95) on the Ohio Achievement Reading Tests than the group that did not use interactive whiteboards (M = 415.55) across all grades. This difference was not statistically significant, F (1, 3128) = 1.477, p = .224, d = .004. However, a statistically significant interaction was found between interactive whiteboard use and grade in school, F (1, 3128) = 2.238, p = 0.048. As shown in Figure 2, students in reading/language arts classes with interactive whiteboards outperformed students in classes without them on Ohio Achievement Tests of reading/language arts in all grades except grades 3 and 7. T-tests run separately for each grade level showed statistically significant differences for grades 5 and 8, t(563) = 2.063, p = .04, d = .20 and t(529) = 2.438, p = 0.015, d = .29 respectively.

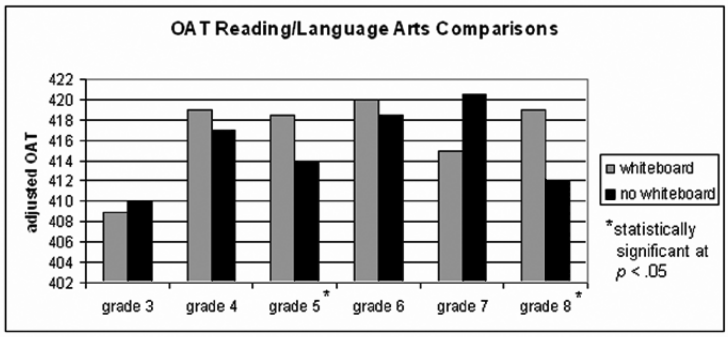

Figure 2. Comparison of Standardized Reading/Language Arts Scores across Grade Levels by Whiteboard Usage

No interactions between gender and interactive whiteboard use, or gender, grade level, and interactive whiteboard use were found.

Summary

Slight positive differences in performance were found between students whose teachers used whiteboards and the students of teachers who did not on standardized tests of reading/language arts and mathematics.

The results were only statistically significant for mathematics achievement and not meaningful for either discipline. However, statistically significant and meaningful differences were found at specific grade levels in both mathematics and reading/language arts performance. One explanation for this might be that due to the number of tests undertaken, the possibility of finding a statistically significant difference increased, so we approached our findings with caution here (Sakoda, Cohen, & Beall, 1954). Even so, while these findings in some respects mirror those of large scale UK studies (Higgins et al., 2005; Somekh et al., 2007) in that they tend to show more positive effects in the lower grades, they are not consistently so. These anomalies led us to consider how individual teachers used interactive whiteboards to explore the possibility that particular kinds of use were more effective than others.

Within-Group Comparisons of Whiteboard Use

The differences in outcomes of whiteboard usage detailed above, especially the significant positive effects at certain grade levels, prompted us to look more closely at how whiteboards were used by different teachers to see if there might be more and less effective ways of integrating such use into classroom routines. In particular, we compared the ways in which interactive whiteboards were used by teachers whose students scored above district means on standardized tests with how they were used by teachers whose students scored at or below the means on standardized tests, using the data from teachers' self-reported weekly usage.

Overall, teachers in the district who had interactive whiteboards reported using them quite frequently, averaging roughly three times per week. Across schools, subject areas, and grade levels, they expressed overwhelmingly positive attitudes toward using the boards. Generally speaking, interactive whiteboard use tended to be more frequent in the elementary grade levels than in higher grades for both mathematics and reading/language arts. However, the frequency of use of interactive whiteboards for classroom management purposes was more consistent across grade levels. Whiteboards were used slightly more often in mathematics teaching than in the teaching of reading/language arts, and they were generally used a little less for classroom management than for either mathematics or reading/language arts teaching. While many teachers simply used their interactive whiteboards as substitutes for chalkboards or overhead projectors, many others reported using them for a variety of purposes, including displaying charts and graphs, connecting to online activities and sources of information, videoconferencing, preparing for the OAT using questions from previous tests, playing educational games, classroom assessment, and student presentations.

Frequency of Use

To explore possible differences in frequency of use of interactive whiteboards between high achieving whiteboard classes and other classes using the same technology, teachers whose average student scores were higher than the mean for all classes on standardized tests of mathematics and reading/language arts were identified. Frequency of whiteboard use among these teachers for mathematics instruction, reading/language arts instruction, and classroom management was compared with frequency of use among teachers whose students scored at or below the mean on the same standardized tests.

There was no difference in frequency of use for classroom management between the two groups. Average use of interactive whiteboards for classroom management was three times per week in both. However there was a considerable difference in the frequency of whiteboard use for instruction between groups. As Figure 3 shows, teachers of students who scored above the mean on standardized tests of mathematics reported using interactive whiteboards an average of 4.7 times per week, while the teachers of students who scored at or below the mean on the mathematics test reported using them only about 3.1 times per week. Similarly, teachers of students who scored above the mean on standardized reading/language arts tests reported using interactive whiteboards an average of 4.6 times per week, while the teachers of

students who scored at or below the mean in reading reported using them an average of only 2.9 times per week.

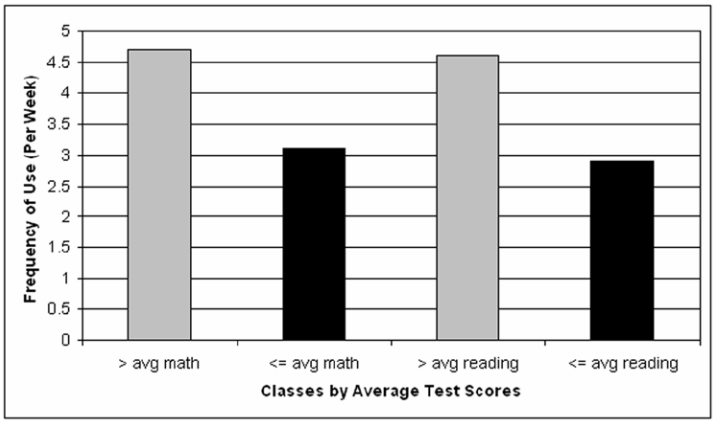

Figure 3. Comparisons of Frequencies of Whiteboard Usage in Reading and Mathematics by Average Test Scores

Characteristics of Use

Teachers' descriptions of the uses they made of interactive whiteboards were qualitatively coded and analyzed for emerging themes. Emerging themes were organized in the general categories "whiteboard functions employed" and "instructional uses" and compared between teachers whose students scored above the mean on standardized tests in each subject area and teachers whose students scored at or below the mean, first in mathematics and then in the area of reading/language arts.

In mathematics classes, teachers reported using whiteboards for simple display, for interacting with charts, graphs, and manipulatives, and to connect to the Internet to access information and interactive activities such as math games. These whiteboard functions were employed to motivate, present subject matter, support preparation for standardized tests, play games, and facilitate whole-group practice and/or assessment activities.

Teachers whose students scored above the mean on standardized mathematics tests were more likely to use whiteboards interactively and to focus whiteboard activities on visualization of concepts and processes, especially problem solving. For example, elementary teachers whose students scored above standardized test means noted,

> *"Students worked with pattern blocks on the board to build fractions using different values, i.e. triangle = 1/4 build a polygon worth 3 3/4; hexagon = 1 what is the value of two rhombuses + 3 trapezoids? etc."*

> *"I've been using it to show students how to get to web-sites for problem solving. We also use the strategies of how to "think through" a problem by modeling it with the actual problems the kids are doing on paper. We did several strategy puzzles too".*

Similarly, a middle school teacher reported,

> *"I used it to teach solving and graphing an inequality on a coordinate graph. I also have my students go to the SmartBoard and complete the x/y table and graph the results."*

The teachers of high achieving mathematics classes also seemed more likely to encourage their students to become active participants in the teaching and learning process. Two teachers in this group, for example, had students create math games they shared with their classmates. One teacher commented,

> "*This type of medium holds interest more than any other I've used in 28 years of teaching. Children take to it so quickly and come up with ideas and alternatives in lessons that I have prepared that we can change on the spot."*

In contrast, although teachers whose students scored at or below the mean on mathematics assessments also were most likely to use the interactive features of whiteboards, they tended to use these for more teacher-centered activities. For example, mathematics teachers in this group reported,

> *"We are in the fractions unit. I designed a PowerPoint presentation called "Fraction Action" to encourage students to get more excited about fractions."*

> *"I used the ruler to demonstrate how to line up for measuring and explained l/2 inch".*

Teachers in this group also seemed more likely to use whiteboards to access Internet activities, such as math games than teachers in the high achieving group. Moreover, many of them commented on the motivational aspects of interactive whiteboard use, whereas none of the teachers with high achieving students did. One teacher in this group wrote, for example,

> *"The Smartboard serves as an incredible incentive for positive behavior. My students are well aware that coming to the Smartboard is a privilege and only students who are quiet and follow instructions are allowed to engage in this activity."*

In reading/language arts classes, teachers reported using whiteboards for simple display, displaying graphic organizers, connecting to the Internet to access information and online activities, and videoconferencing. These functions were employed to motivate, present subject matter, support preparation for standardized tests, play games, for student presentations, and to support special needs students.

Perhaps even more so than in mathematics, the contrast between reading/language arts teachers whose students scored above the mean on state assessments and teachers whose students scored at or below the mean seemed to be between student-centered and teacher-centered uses of the whiteboards. For example, teachers whose students scored above the reading/language arts mean were more likely to use whiteboards to support student presentations:

> *"Students gave PowerPoint presentations they created for a book share, using Inspiration webs and propaganda techniques to persuade others to read the books."*

In contrast, teachers whose students scored at or below the mean were more likely to use interactive whiteboards in their own presentations, for example:

> *"I used it to practice singular and plural possessives. I wrote sentences and children put the apostrophe where it belonged. I could move the apostrophe from before the 's' and after the 's' to demo the difference."*

Teachers of high-achieving students also tended to use the whiteboards to support visualization of concepts with activities such as concept mapping, brainstorming, and interactive editing. They used their whiteboards in incredibly creative ways including videoconferencing with other classes to support group

work over distance and for developing and presenting poetry as music videos. One of these teachers, for example, wrote:

> *"During the week we correct grammar sentences, we rearrange words too as part of peer editing; we take notes, watch movies, share student PowerPoints and graphic organizers."*

In contrast, teachers whose students scored at or below reading/language arts means on the state test often used the whiteboards for more mundane tasks such as simple display of assignments, vocabulary words, and worksheets. Many of these teachers also used the interactive whiteboards to play a variety of language games and used the built-in timer function for timed seatwork. For example, two teachers in this group reported:

> *"Timer to keep students on track; daily list of what will be covered in class; sharing vocabulary words on the board."*

> *"We complete workbook pages at the SmartBoard rather than individually at seats."*

Summary

When differences in the ways in which the teachers used whiteboards were compared between teachers of high-achieving students and teachers whose students scored at or below district means, several important differences surfaced. First, the teachers of high-achieving students used their whiteboards almost every day, whereas the teachers of average or low-performing students used them an average of three times per week. Second, a qualitative difference between usage patterns among the two groups of teachers emerged. Teachers of high-achieving students used their whiteboards in more student-centered ways than did the teachers of students who scored at or below the means. In addition, teachers of high-achieving students reported usage that tended toward employing whiteboards to support the visualization of concepts and creativity, whereas teachers of students who scored at or below district means tended to use them mainly for presentation and motivation.

DISCUSSION

The results of this exploratory study show a small statistical difference in achievement between students whose teachers used interactive whiteboards for reading/language arts and mathematics instruction and students whose teachers did not use them. The overall differences were quite small and not really meaningful, and are statistically significant only in mathematics. However, statistically significant and meaningful differences between groups were found at specific grade levels – at the fourth and fifth grade levels in mathematics, and at the fifth and eighth grade levels in reading/language arts. These differences, combined with significant interactions between grade level and whiteboard use, prompted us to explore the possibility that differences in the ways in which teachers used interactive whiteboards made a difference in their effectiveness. The results of these comparisons suggest that they do.

When teachers were grouped by their students' mathematics and reading/language arts performance on the state achievement tests, teachers whose students scored above the district mean on one or both assessments were found to use the whiteboards more frequently (almost every day) than the teachers whose students scored at or below the means on these tests. More importantly, the teachers of high-achieving students used their whiteboards qualitatively differently from teachers in the comparison group. Teachers in the former group used whiteboards in a more student-centered manner and primarily to support the visualization of concepts, while teachers in the latter group used whiteboards in a more teacher-centered manner and primarily for presentation and motivation purposes. Thus it may be that

certain kinds of teaching strategies resonate more with the particular affordances of interactive whiteboards to better enhance learning.

FUTURE RESEARCH DIRECTIONS

The findings thus suggest that the ways in which interactive whiteboards are used affects their efficacy. Findings concerning frequency of use may indicate a kind of tipping point in usage that needs to be reached first, or alternatively, that the more integral a part of daily classroom activities whiteboard usage becomes the more effective they are in enhancing learning. Findings concerning the ways in which whiteboards are used suggest that more active and constructivist uses are more effective, as are uses that focus on the visualization of concepts. These results seem to build on findings from the literature which suggest that whiteboard use can lead students to refocus their attention away from the teacher and onto academic content, perhaps suggesting that this only happens when teachers allow it. They may also indicate that the most effective uses of the technology are those that take advantage of its more unique capabilities, such as support for visualization and interactivity.

Of course, the nature of our study makes it impossible to tell whether the teachers whose students excelled on district tests were just better teachers than the comparison teachers. As, Higgins, Beauchamp and Miller (2007. p. 217) remark, "Good teaching remains good teaching with or without the technology." However, even if we could tell the difference, the results then indicate that better teachers take full advantage of interactive whiteboards by making their use a more integral part of their classroom activities and by capitalizing on their unique affordances.

In any case, the results are provocative and clearly indicate that further investigation of the more effective uses of interactive whiteboards should be undertaken. For example, quantitative research is needed to investigate how frequency of use, types of use, or a combination of both affect student learning, and in particular, what types of learning. Second, investigations that look more specifically at the affordances that interactive whiteboards provide can yield useful information, particularly in the areas of digital visualization and human computer interaction, including direct manipulation of objects on the screen (i.e. without an intermediary input device such as a mouse, keyboard, or stylus). Third, research needs to determine best practices for teaching with interactive whiteboards, in order to inform practitioners as well as professional development efforts.

CONCLUSION

This study explored the effects of teachers' uses of interactive whiteboards on student performance in reading/language arts and mathematics. Reading/language arts and mathematics achievement test scores of all students in the third through eighth grades in a small urban school district in northern Ohio were compared between students whose teachers used interactive whiteboards for instruction and those whose teachers did not. Statistically significant and meaningful interactions between whiteboard use and grade levels were found, leading to a more careful look at differences in the ways in which whiteboard-using teachers employed them in their instruction. A within-group comparison of such usage between teachers whose students scored above the mean on standardized tests and those whose students scored at or below the mean revealed that the teachers of high-scoring students used interactive whiteboards more frequently and in more creative and constructivist ways than did teachers whose students performed at or below the mean.

In sum, the results from our study show that the use of interactive whiteboards can make a difference in academic achievement, but that such a difference seems dependent on how teachers use them. As more and more classrooms, schools, and school districts are acquiring digital technologies like interactive

whiteboards, this is perhaps our most important finding. For teachers and schools to make good use of what can be a considerable investment, effective uses of interactive whiteboards should be more thoroughly and robustly explored.

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[1] Ohio's accountability system ranks schools and districts according to their performance on a combination of academic indicators, a performance index score, and adequate yearly progress. Possible rankings include Excellent, Effective, Continuous Improvement, Academic Watch, and Academic Emergency. A school or district in Academic Watch has met 31.0-49.9% of academic indicators or has a performance index score of 70-79.9 (on a scale of 0-120), *and* has not met the adequately yearly progress. For more information see http://www.ode.state.oh.us/GD/Templates/Pages/ODE/ODEDetail.aspx?Page=3&TopicRelationID=1266&ContentID=52790&Content=52818