Interactive whiteboards produce small gains in elementary students' self-reported motivation in mathematics

Bruce Torff *, Rose Tirotta
Hofstra University, United States

A B S T R A C T

A treatment/control study (N = 773) was conducted to determine the extent to which use of interactive whiteboard technology (IWB) was associated with upper elementary students' self-reported level of motivation in mathematics. Students in the treatment group reported higher levels of motivation relative to control students, but the effect was extremely weak. Students with teachers who were more supportive of IWB technology reported higher motivation levels (compared to students of teachers who were less supportive), but this effect also was very small. Claims about the motivation-enhancing effects of the IWB are not baseless, but they appear to be somewhat overstated. Research is needed to determine how IWB-use is associated with academic performance, and also to examine how teachers use the IWB and how this usage could be strengthened.

1. Introduction

Use of interactive whiteboards in schools has become widespread in many countries around the world. This proliferation has taken place despite the nontrivial cost of purchasing and maintaining interactive whiteboard (IWB) technology and the sometimes-considerable burdens of training staff to use them effectively. Apparently the IWB is seen as offering a range of benefits, including increases in student motivation (BECTA, 2003; Beeland, 2002; Burden, 2002; Damcott, Landato, Marsh, & Rainey, 2000; Hall & Higgins, 2005; Hennessy, Deane, Ruthven, & Winterbottom, 2007; Levy, 2002; Schmid, 2008; Slay, Siebörger, & Hodgkinson-Williams, 2008; Smith, 2000; Thompson & Flecknoe, 2003; Weimer, 2001). On this view, the technological capabilities of the IWB and its attendant software are highly compelling to students, effectively drawing them into the content of the lesson. Investment of financial and human resources in IWB technology is seen as warranted in part because it promises to make learning more engaging for students, especially in technical subjects (e.g., mathematics) in which teachers sometimes struggle in their efforts to help students engage and achieve.

The claim that the IWB helps to motivate students has been supported by research initiatives using qualitative methods. A portion of these studies involved student self-report procedures using interviews and focus groups (Hall & Higgins, 2005; Hennessy et al., 2007; Levy, 2002; Schmid, 2008; Slay et al., 2008; Thompson & Flecknoe, 2003). For example, Schmid (2008) conducted interviews and focus groups with 62 students who had participated in IWB-assisted lessons during two eight-week English classes held over two summers. The results were positive: students reported that the IWB made the lessons more interesting, attractive, exciting, and motivating, and it helped them concentrate on the content at hand. Comparable findings were reported in studies employing interviews with students conducted by Hall and Higgins (2005), Levy (2002), and Thompson and Flecknoe (2003).

In a study focused on classroom activities in which students manipulated objects on the IWB, Hennessy et al. (2007) interviewed six students in two classes in which IWB-assisted activities had been implemented. Interviewees (as well as their teachers) suggested that students' motivation level was enhanced by IWB functions that allowed students to manipulate items on the board.

One study assessed student motivation using classroom-observation methods. In research focused on lessons that used mathematics software in conjunction with the IWB, students were observed in two IWB-assisted classes at different grade levels, with 16 students in one class and 13 students in the other (Thompson & Flecknoe, 2003). The observers reported that students were highly attentive in IWB-assisted lessons, and also that classroom disruptions became less frequent.
Other studies utilized teacher reports to assess the motivational properties of IWB technology (Burden, 2002; Hennessy et al., 2007; Levy, 2002; Slay et al., 2008). For example, Burden (2002) conducted interviews with 200 teachers who used the IWB in their classrooms. The teachers reported increases in student motivation that were attributable, in their view, to the use of the IWB. Similar results were produced in teacher interviews conducted by Levy (2002). In this study, 11 teachers in two schools reported that students seemed to find learning with the IWB more enjoyable and that IWB technology increased students’ level of motivation.

Slay et al. (2008) combined observations and teacher interviews in research involving case studies with three teachers who had been trained in the use of the IWB. Each teacher was observed at least three times and interviewed at least twice. In the teachers’ judgment, use of up-to-date technology (including the IWB) was a positive factor for student motivation, in particular due to the size of the projection screen and the use of multimedia in IWB-assisted lessons.

In addition to these qualitative studies, quantitative research has been conducted to substantiate the claim that the IWB has potential to enhance student motivation. In one such study, a questionnaire was given to 286 students in two schools (Levy, 2002). Students indicated that the IWB made learning more fun and more interesting: 57% in one school and 63% in the other indicated that IWB-assisted lessons were more fun than lessons that did not use the IWB. Moreover, 57% and 68% of the students at the two schools (respectively) reported these classes to be more interesting than lessons in which the IWB was not used.

Wall, Higgins, and Smith (2005) conducted survey research in which 80 students filled out templates with questions that asked them what they thought of the IWB and what they were likely to share with others about this technology. A total of 1568 responses were analyzed; 883 of the statements were judged to be positive, 494 statements were scored as neutral, and 191 were judged to be negative. Positive statements were then broken down into subcategories, with “motivation” and “fun” each noted in over 120 responses. The researchers concluded that students deemed the IWB to be motivational and fun, especially when students were able to see their work projected on the IWB screen.

In other survey research, Beeland (2002) measured student engagement and motivation in 10 classes that featured IWB-assisted lessons. Surveys were completed by 197 participating students. The surveys included 20 Likert-scale items with which respondents rated their level of agreement (1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree). The grand mean of all 20 items was 3.48, midway between “agree” and “strongly agree”, and all answers averaged 3.0 (“agree”) or higher. The most favorable scores were obtained with items that tapped student enjoyment of lessons using the IWB in the classroom. In addition, correlations were computed between the survey results and (a) the frequency with which the IWB was used and (b) the frequency with which students interacted directly with the IWB in the classroom. A positive correlation was found between student support for IWB and the frequency with which the IWB was used (although the magnitude and significance level for this correlation were not reported). No significant correlation was obtained between student support for IWB and the frequency with which students were afforded opportunities to interact directly with the IWB in the classroom.

In survey research conducted in small college-level physics classes, students participated in lessons in which they were asked to manipulate the IWB during classroom activities (Damcott et al., 2000). Students then completed a survey with eight Likert-scale items and two free-response questions. On the scale items, more students supported the use of the IWB than did not. On the free-response items, some students indicated they enjoyed writing on the board, whereas others were attracted to the IWB’s drag-and-drop features.

One study employed a control group in an investigation of the extent to which the IWB helps to boost student motivation (Weimer, 2001). Forty-nine students completed two projects arranged in an alternating design: in one group students first completed the IWB-assisted project and then the unassisted one, and in the second group the projects were reversed. After each project, students completed a seven-item survey assessing students’ self-reported motivation level in that project. Students reported a 50% higher level of motivation in IWB-assisted lessons, and scores under IWB-assisted conditions were higher for all survey items except for one. At the same time, a single teacher taught both classes, and although the experimental design was double blind, it cannot be ruled out that teacher bias influenced the instruction (and potentially the results). Moreover, this study used a control group but was small in scale, with only 26 students in one class and 23 in the other. It thus lacked sufficient statistical power for the inferential statistics needed to compare student performance under IWB-assisted and unassisted conditions.

Overall, there is a substantial body of research pointing to increases in student motivation when IWB technology was used in the classroom (Beeland, 2002; Burden, 2002; Damcott et al., 2000; Hennessy et al., 2007; Levy, 2002; Slay et al., 2008; Smith, 2000; Thompson & Flecknoe, 2003; Wall et al., 2005). But evidence to support the claim that the IWB enhances motivation remains weak. In particular, only one study employed a control group (Weimer, 2001), and this small study lacked needed inferential statistics. As a result, it remains unclear the extent to which students taught using the IWB differ in motivation relative to students taught without this technology. The research reported below moves into the breach by employing a treatment/control design with a larger population, and using inferential statistics, with the goal of examining the impact of IWB technology on students’ self-reported motivation in mathematics lessons in the upper elementary grades.

2. Methods

The study involved teachers and students in 3rd, 4th, and 5th grade classes in a single school district in suburban New York City (USA). In essence, the research entails a quantitative case study of students and teachers in that district. As with any case study, care must be taken in generalizing the findings to other populations of students and teachers. At the same time, a case study approach confers advantages in this instance. Collecting data in one district only allows policies and practices for use of educational technology (and in particular, the IWB) to be held constant across the sample studied. Policies and practices as such vary substantially from one district to the next; in some districts, emphasis on IWB technology is strong and the hardware has been installed in every classroom, while in other districts the technology is minimal or nonexistent. Collecting data in a single district reduces contamination possibly caused by variance across districts in technology-related policies and practices.

The participating district is in an upper-middle-class community of about 25,000 people near New York City (USA). It is a diverse community; the approximately 3000 students come from over 30 countries. The study body is approximately 40% white and 40% Asian with growing populations of Hispanic students and recent immigrants.
The district had made a substantial commitment to IWB technology. About three years before the study was conducted, IWB facilities had been installed in all classrooms in the district and programs were launched to train teachers to use them. However, participation in the training sessions was voluntary, and a group of technology-oriented teachers opted to delve into the IWB while some of their colleagues chose not to.

As a result, the district provides a useful setting for this research. All teachers had unrestricted access to IWB technology, and the district included classrooms in which the IWB had been pressed into use (a treatment group) and others in which it had not (a control group). Moreover, since IWB units had been installed in all classrooms well before the study was conducted, it is unlikely that the results stem from a short-term novelty effect that sometimes accompanies technological innovations in the classroom (BECTA, 2003; Levy, 2002; Miller & Glover, 2002; Smith, 2000).

To assign teachers (and their students) to groups, teachers were given a brief survey asking them to rate the extent to which they used the IWB in their math teaching. The question was presented as a four-part Likert scale, in which 1 = no use of the IWB, 2 = little use of the IWB, 3 = moderate use of the IWB, and 4 = extensive use of the IWB. Teachers responding with a “1” or “2” were assigned to the control group, and teachers answering “3” or “4” were placed in the treatment group. (In support of this grouping procedure, we report below that teachers in the two groups differed significantly in attitudes about utility of IWB technology in the classroom.) Students received the same group assignment as their teacher, since the extent of teachers’ classroom use of the IWB was the grouping variable employed in this research.

The study was focused on a single academic subject, mathematics. Not only is mathematics a subject of considerable importance in modern schools; it is also a subject in which educational technologies are frequently employed, in part because of the technical nature of the subject and in part because a great deal of software for mathematics instruction has been marketed.

To assess students’ self-reported level of motivation about mathematics, a survey was designed and implemented. Seven survey items were constructed for this assessment, five of which were ultimately included in the factor model described below (Fig. 1). The items were designed to cover a range of attitude responses relevant to motivation in mathematics lessons in the upper elementary grades. All items were scored on four-point Likert scales with various descriptors. The survey also asked students to indicate their gender, so that the influence of students’ gender on their self-reported motivation level could be evaluated.

In addition, a teacher survey was created to assess teachers’ attitudes about the IWB, based on the possibility that the strength of this support may be associated with students’ motivation level in IWB-assisted lessons. Ten survey items were constructed for this assessment, encompassing various aspects of use of IWB technologies in the classroom (Fig. 1). All items were scored on four-point Likert scales in which 1 = strongly disagree and 4 = strongly agree. The teacher survey also asked respondents to indicate their gender, years of teaching experience, and level of educational attainment (bachelor’s degree; master’s degree; master’s degree plus 30 credits; master’s degree plus 60 credits; doctoral degree).

The surveys were administered to teachers and students in their classrooms in spring of 2008. All individuals asked to participate did so, and none were compensated. They were given instructions indicating that these opinion surveys had no correct answers, and all responses were confidential.

3. Results

The study’s participants included 773 students (241 students in 4th grade, 260 in 5th grade, and 232 in 6th grade). There were 32 participating teachers: 19 who indicated they were IWB users (the treatment group) and 13 who indicated that they were not extensive users

---

**Student Survey Items**

1. How much have you liked mathematics this year? (a lot, some, a little, not much)
2. How fun has mathematics been this year? (very fun, sort of fun, a little fun, not fun)
3. How easy has it been to pay attention in mathematics this year? (very easy, sort of easy, pretty hard, very hard)
4. How hard have you worked in mathematics this year? (very hard, sort of hard, not too hard, not hard at all)
5. How confident have you felt in mathematics this year? (a lot, some, a little, not much)

**Teacher Survey Items**

1. The IWB has potential to enhance student engagement in mathematics lessons.
2. The IWB has potential to make mathematics learning more fun for students.
3. The IWB has potential to enhance student performance on standardized mathematics tests.
4. I am likely to make extensive use of the IWB in the future.

---

**Notes:**

All teacher-survey items were scored as follows: strongly agree, agree, disagree, strongly disagree.

Both the student survey items and the teacher survey items were selected from a gallery of candidate items using data-reduction techniques including factor analysis and internal-consistency reliability analysis.

---

*Fig. 1. Survey items.*
of the IWB (the control group). The treatment group included 458 students and the control group had 315 students. (See Table 1 for additional descriptive statistics.)

The dependent variable was students' self-reported motivation in mathematics, as assessed by a student survey. The independent variables included group (treatment versus control), grade level (3rd, 4th, or 5th), student's gender, teachers' attitudes about IWB (assessed by the teacher survey), teachers' years of teaching experience, teachers' gender, and teacher's level of educational attainment.

### 3.1. Teacher assessment

An exploratory factor analysis using the principal components method was performed on the 10 items of the teacher-assessment survey. The Kaiser MSA overall score was found to be 0.81 and all individual-item MSA scores were above 0.86, indicating that the data were suitable for factor analysis. A single factor was indicated; one factor emerged with an eigenvalue of 3.39, and the second factor's eigenvalue was 0.69. Four items loaded satisfactorily on the factor and were retained in the final, reduced factor model. The single-factor model accounted for 66% of the variance in the four items and could be readily interpreted in accordance with the theoretical aims of the instrument (assessment of teachers' attitudes about the utility of IWB technology). The single-factor model produced a residual matrix root mean square error of 0.06. The model had satisfactory internal consistency reliability, with an alpha of 0.82.

For the four items included in the factor model, the mean score in the IWB group was 3.72 (SD = 0.74). In the control group the mean was 2.62 (SD = 0.89). Unsurprisingly, teachers in the treatment group were significantly more supportive of the IWB than were teachers in the control group: F(1, 31) = 47.98, p < 0.01; partial eta-square = 0.49. This assessment of teachers' attitudes about the IWB proved helpful as a covariate measure in the student assessment, described below.

### 3.2. Student assessment

An exploratory factor analysis using the principal components method was performed on the seven items of the student-assessment survey. The data were suitable for factor analysis, with a Kaiser MSA overall score of 0.91 and individual-item MSA scores above 0.89. A single factor was indicated, interpreted as an assessment of students' self-reported level of motivation in mathematics. The first factor had an eigenvalue of 2.99, while the second factor's was 0.93. Five items were associated with the factor and were retained in the reduced model. The five-item, single-factor produced an alpha of 0.89 and a residual matrix root mean square error of 0.05. For the five items included in the student-assessment factor model, the IWB group yielded a mean score of 3.47 (SD = 0.80). The control group produced a mean of 3.22 (SD = 0.88).

Analysis of Covariance (ANCOVA) was performed to determine the extent to which students' attitudes about mathematics differed across groups, controlling for (a) grade level, (b) students' gender, (c) teachers' attitudes about IWB, (d) teachers' years of teaching experience, (e) teachers' gender, and (f) teachers' level of educational attainment. Results of Levene's test of homogeneity of variance were satisfactory, as were normal probability plots.

The variable teachers' attitudes about the IWB made a significant contribution to the variance in students' self-reported motivation level in mathematics, although the effect was quite small (p < 0.05; partial eta-squared = 0.02). Students with teachers who were more supportive of IWB technology reported slightly higher motivation levels (relative to students of teachers who were less supportive). The remaining four independent variables made no significant contribution to the variance in students' motivation level and were dropped from the model: teachers' gender, teachers' level of educational attainment, students' gender, and grade level.

In the revised model, a statistically significant difference between groups was obtained: F(2, 770) = 6.98, p < 0.05; partial eta-square = 0.01). Relative to students in the control group, students in treatment classes reported a slightly higher level of motivation in mathematics lessons, controlling for teachers' attitudes about the IWB.

### 4. Discussion

For many educators, IWB technology has enormous potential to improve learning and teaching in school. It has been claimed that the technological capabilities of the IWB (and its attendant software) have a powerful allure for students – a “that’s so cool” factor that boosts student motivation (e.g., BECTA, 2003). On this view, investment of financial and human resources in IWB technology is warranted in part because it promises to make learning more engaging for students, especially in technical subjects (e.g., mathematics). This claim has been supported in qualitative research projects (Burden, 2002; Hall & Higgins, 2005; Hennessy et al., 2007; Schmid, 2008; Slay et al., 2008;...
Thompson & Flecknoe, 2003), and also in survey studies conducted without experimental controls (Beeland, 2002; Levy, 2002). One survey study included a control group (Weimer, 2001), but it employed a very small sample and lacked inferential statistics comparing student performance under IWB-assisted and unassisted conditions. Consequently, it remains unclear the extent to which IWB lessons are associated with increases in student motivation, and if so, how much.

The research reported in this article presents such a study, with mixed results. Students exposed to IWB-assisted lessons reported a slightly higher level of engagement in mathematics classes, relative to a control group taught without the IWB. And teachers’ attitudes about the IWB were associated with slightly higher levels of motivation; in other words, teachers who strongly supported using the IWB (and likely used the technology well) produced larger motivational effects in their students. By the glass-half-full approach, these findings provide controlled-study evidence that student motivation is increased by the IWB and the teachers who believe in using it. But the motivation-enhancing effect of the IWB found in this study was very weak. With an effect size (partial eta-squared) of a 0.01, the obtained effect was nearly too small to detect. And since this study sampled a reasonably large group of students (773 in the two groups), it had sufficient statistical power to ensure that the diminutive effect size was not simply an artifact of a small sample. The data suggest that the IWB increases student motivation, but only by the slimmest of margins.

Consequently, the IWB-is-motivating claim alone does not appear to serve as a suitable rationale for investments in IWB technology, which requires a sizeable, ongoing allocation of financial and human resources (e.g., funds to purchase, install, and maintain the IWBs and ongoing efforts to train staff to use them). Studies of the academic outcomes of the IWB are needed, as described in the final section below.

4.1. Limitations and future research

As with any case study, generalization of the results reported here must be undertaken with caution. It remains unclear to what extent, and in what ways, the district studied in this research is representative of other populations of students and teachers in other school districts and geographical regions. Research in other settings is needed; of particular interest would be studies in communities that differ in socioeconomic status, since more affluent students may have more access to technologies and thus may respond differently to the IWB. This study was focused on upper elementary students, some of whom received IWB-assisted math lessons. Research examining the predilections of other students, both younger and older, may produce different results. Similarly, this study involved mathematics lessons only, and the effects of the IWB may vary when this technology is employed in other academic subjects.

Future research might well employ experimental methods. In this study, group assignment was the product of self-selection; teachers chose whether to use the IWB in their classrooms. It seems probable that teachers who opt to use the IWB are inherently dissimilar from teachers who opt not to, and as a result the differences obtained in this study likely stem from teachers’ attitudes toward the technology rather than from the technology itself. A study conducted using a randomized-trial design (that is, in which teachers are randomly assigned to the treatment or control group) would provide more compelling evidence of the impact of IWB technology on student motivation.

Studies are also needed examining in greater detail how the IWB is used in the classroom and what kinds of results these various uses produce. In particular, it seems useful to draw a distinction between comparatively simple IWB-assisted lessons that could be accomplished with a computer and projector (e.g., projecting PowerPoint slides) and lessons using more complex and interactive IWB functions (e.g., the interactive functions inherent in Geometer’s Sketchpad). But it is not known how these simple and complex uses differ in fostering student motivation. Neither is it known how teachers typically use the IWB, or what kinds of different outcomes these various uses yield, or what kinds of professional development are most effective in promoting effective use of IWB technology.

Finally, as noted, research is needed examining the extent to which the IWB is associated with increments in students’ academic outcomes. As important as studies of motivation are, the finding that IWB technology can be motivating is of limited utility unless it is accompanied by significant gains in students’ academic achievement. Studies are needed examining the extent to which classroom use of the IWB is associated with differences in test scores and performance assessments in a variety of subjects. Research might well explore how best to use this powerful teaching tool, and how to train teachers to use it effectively.

References


