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IESD WHITE PAPER

What the Research Says: Using eInstruction's® Insight 360™ System to Support Effective Instruction

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A Summary of Independent Research

Prepared by Interactive Educational Systems Design, Inc. for eInstruction®

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Introduction

Over the past several years, both student response systems and shared display and interaction technology such as interactive whiteboards (IWBs) have become important tools in K-12 classrooms (Beatty & Gerace, 2009, pp. 146-147; Thomas & Schmid, 2010, p. xvii). A substantial body of evidence supports the potential instructional value of such systems when used to support effective instructional practices such as formative assessment, teacher questioning, and making learning interactive.

eInstruction's® Insight 360 combines the capabilities of a student response system with mobile interactive whiteboard technology and integrated content as part of a complete mobile formative instruction system. The purpose of this white paper is to summarize evidence related to effective instructional practices and to show how eInstruction's Insight 360 system supports research-based, effective instruction.

This paper draws on research related to:

- Use of student response systems in education
- Use of interactive whiteboards in education
- Formative assessment and related instructional strategies, including:
  - Feedback to students as part of the formative assessment process
  - Changing student misconceptions
  - Modifying teaching in response to formative assessment data
- Effective questioning techniques used by teachers

Insight 360™ in a Nutshell

Key elements of Insight 360 include the following:

- A Mobi 360 teacher mobile device or Mobi 360 for iPad application that can be used to control the Insight 360 system from anywhere in the classroom
- A projector
- Up to 4 Mobi mobile devices that can be used by individual students or small groups to interact with the display
- Individual student response ("clicker") devices (e.g., Spark or Pulse)
- A computer for teacher use
- A receiver that enables wireless connectivity among Insight 360 components
- Insight 360 system software that links the devices together and provides reporting and analysis capabilities

- Tagging software that allows any question in any format or language to be "tagged" as a question for immediate recognition by the Insight 360 software
- Instructional and assessment content, including ExamView® assessment resources

Common instructional models for using Insight 360 that align to research described in this paper include the following:

- Ask questions prior to a class discussion to identify prior knowledge and possible misconceptions
- Present engaging multimedia content to the entire class using the display system
- Ask questions during a class discussion or activity to monitor student understanding and adjust instruction as needed
- Display class responses and use the display as a basis for discussion
- Intersperse class discussions and presentations with questions to emphasize important content, add interactivity, and engage student attention
- Assign tasks that students complete either individually or in groups using their Mobi devices to interact with the display

About This White Paper

This white paper includes the following informative sections:

- An executive summary presenting key findings from the body of research
- Separate sections presenting more detailed research results related to specific types of technology:
  - Research on student response systems
  - Research on interactive whiteboards (IWBs)
- Separate sections presenting more detailed research results related to specific instructional strategies and approaches:
  - Value of feedback
  - Addressing student preconceptions and misconceptions
  - Modifying teaching in response to formative assessment data
  - Teacher questioning
  - Promoting student interactivity and engagement
- Conclusion

Executive Summary—Key Findings

Research presented in the sections that follow supports the following findings:

- Research on student response systems such as that incorporated into Insight 360 suggests that they promote learning when coupled with appropriate pedagogical methodologies (Beatty & Gerace, 2009; Fies & Marshall, 2006; Kay & Knaack, 2009; Penuel et al., 2007; Roschelle et al., 2004a, 2004b).
- Many researchers of interactive whiteboards have found that this technology—which has been incorporated into Insight 360 in a mobile format—has a positive impact on student engagement (Glover et al., 2005; Higgins, 2010; Miller & Glover, 2010; Smith et al., 2005; Thomas & Schmid, 2010). Research on IWBs also suggests that shared display and interaction technology provides capabilities for presenting content information and concepts effectively using multimedia and multiple sources, and in some cases is associated with improved student learning (Glover et al., 2005; Higgins et al., 2007; Lewin et al., 2008; Marzano, 2009; Marzano & Haystead, 2009; Miller & Glover, 2010; Smith et al., 2005).
- Insight 360 offers effective support for students to receive focused, timely feedback as part of the process of formative assessment, of the type that has been shown to improve learning (Bangert-Drowns et al., 1991; Barron et al., 1998; Black & Wiliam, 1998a, 1998b; National Research Council, 2000; Tierney & Charland, 2007; Vye et al., 1998).
- Insight 360 provides powerful tools for addressing student preconceptions and misconceptions through the use of formative assessment, with important research-based implications for student learning (Abrahamson, 2006; National Research Council, 2000).
- Insight 360 facilitates frequent, timely formative assessment that can be used to guide adjustments to teaching—an instructional practice that has been found to have a powerful impact on student learning (Barootchi & Keshavarz, 2002; Black & Wiliam, 1998a, 1998b; Dori, 2003; Fies & Marshall, 2006; National Research Council, 2000; Nunes, 2004; Penuel et al., 2007; Roschelle et al., 2004a, 2004b; Tierney & Charland, 2007; Vendlinski & Stevens, 2002). This includes use of formative assessment to support differentiated instruction (Hall, 2002; Tomlinson, 2000).
- Insight 360 offers effective support for research-based teacher questioning strategies (Black & Wiliam, 1998b; Crooks, 1988; Ellis, 1993; Gall & Rhody, 1987; Wilen, 1987).
- Insight 360 incorporates capabilities that can make classroom lessons more interactive, thereby raising student interest and engagement (Fies & Marshall, 2006; Gall & Rhody, 1987; Kay & Knaack, 2009; Penuel et al., 2007; Roschelle et al., 2004a, 2004b). In particular, Insight 360's support for teacher mobility and direct student interaction with the display provide important advantages over standard IWBs, in terms of supporting instructional best practices (Higgins, 2010; Lewin et al., 2008; Marzano & Haystead, 2009; Miller & Glover, 2010; Smith et al., 2005; Thomas & Schmid, 2010).

Research on Student Response Systems

Research Findings

Reviewing the body of direct research on student response systems (SRS)[1] such as that incorporated into Insight 360, Fies and Marshall (2006) reported, "There is great agreement that [student response systems] promote learning when coupled with appropriate pedagogical methodologies.... The literature also indicates that [SRS]-supported environments lead to greater learning gains than traditional learning environments" (p. 106)[2].

Out of 16 implementation studies examined directly by Fies and Marshall, the most common outcomes were as follows (see Appendix, p. 107):

- "Higher participation, more engagement" (9 studies)
- "Instructor more aware, more responsive instruction" (7 studies)
- "Students self-monitor understanding, understand more" (7 studies)
- "Better communication" (6 studies)
- "More interest, more enjoyment (fun)" (6 studies)
- "More formative assessment" (5 studies)

Fies and Marshall also cited an analysis of 26 classroom network studies by Roschelle et al. (2004a, 2004b)[3] that found evidence of the following (see Fies & Marshall, 2006, p. 103):

- "[G]reater student engagement" (16 studies)
- "[I]ncreased student understanding of complex subject matter" (11 studies)
- "[I]ncreased student interest and enjoyment" (7 studies)
- "[H]eightened discussion and interactivity" (6 studies)
- "[I]ncreased student awareness of individual levels of comprehension" (5 studies)
- "[I]ncreased teacher insight into student difficulties" (4 studies)

Additional information provided by Roschelle et al. indicates that this body of research should be considered suggestive rather than conclusive.

Summarizing results of previous higher education research on student response systems, Kay and Knaack (2009, p. 383) identified benefits similar to those noted above:

- "[S]tudent attitudes toward [student response systems] are very positive."
- "[S]tudents are more engaged in the content presented..., participate more..., and pay more attention to concepts presented."
- "[U]sing [student response systems] improves the feedback cycle between instructor and students with the rapid, anonymous, collection and presentation of all student responses to questions asked."
- "Many higher education students report that they learn more when [student response systems] are used.... [T]here is substantial qualitative and quantitative evidence to suggest that learning performance increases as a direct result of using [student response systems]."

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[1] These are also referred to as classroom response systems or audience response systems in some of the research literature.
[2] Most of this body of research was from higher education.
[3] These were a mix of studies from K-12 and higher education.

K-12 Research

Penuel and colleagues (2007) surveyed 584 elementary and secondary educators across multiple grade ranges and subject areas on their use of eInstruction's Classroom Performance System (CPS), an earlier version of the student response system incorporated into Insight 360. When asked about the effects of the system, teachers awarded a mean score between 4 (agree) and 5 (strongly agree) on a scale of 1-5 for each of the following statements (see Table 2, p. 334):

- "The CPS helps me tell if the students understand a concept" (*M* = 4.38, *SD* = .62)
- "Class interactions resulting from using the CPS help student learning" (*M* = 4.24, *SD* = .71)
- "With the CPS, students can quickly tell whether they are right or wrong" (*M* = 4.51, *SD* = .83)
- "I have better-quality information about students' understanding through the use of the CPS" (*M* = 4.19, *SD* = .774)
- "By using the CPS, I have more timely information about what students know" (*M* = 4.46 *SD* = .68)
- "I have been able to adapt instruction better to specific student needs or misconceptions by using the CPS" (*M* = 4.05, *SD* = .79)
- "Doing activities with the CPS in class helps students get a better understanding of concepts" (*M* = 4.07, *SD* = .69)
- "Students are more actively engaged in a CPS class than in others" (*M* = 4.37, *SD* = .76)

The researchers also found that "[f]requent, broad users of the CPS were much more likely to perceive the CPS as conferring a range of benefits to themselves and to students" (p. 340). While the subjects of this study do not constitute a representative sample of all SRS-using teachers, these findings suggest that K-12 teachers who use eInstruction's student response system technology perceive benefits from its use similar to those identified in higher education studies.

Kay and Knaack (2009) found similar results from a survey of 213 grade 10-12 students in science classes taught by seven teachers who made limited use of an eInstruction SRS. A majority of the students agreed with the following statements (see Table 1, p. 385):

- "Using clickers was a good way to test my knowledge" (74%; includes students who slightly agreed, agreed, and strongly agreed with the statement)
- "I was more engaged in the lesson when clickers were used" (70%)
- "I was more motivated when clickers were used" (63%)
- "I participated more than I normally would when clickers were used" (62%)
- "I would prefer to use clickers" (62%)
- "I liked seeing what other students in the class selected for answers" (56%)
- "Using clickers generated more class discussion" (53%)

Equally noteworthy was the difference in responses from students in classes where the system was being used for formative assessment versus those where it was being used for summative assessment. According to the researchers:

> Using [a student response system] for formative assessment was rated significantly more positively than using [a student response system] for summative assessment on all 11 Likert scale items in the... attitude scale. Using [a student response system] for formative assessment also resulted in significantly higher scores on most survey items when compared to a mixed approach (formative & summative). (p. 388)

Importance of Instructional Approach

The difference in student attitudes reported by Kay and Knaack (2009) for formative assessment versus summative assessment uses of student response systems (reported above) underscores the fact that student response systems are tools for carrying out specific pedagogical approaches, and that the impact of such systems depends on the instructional strategies that are used. Beatty & Gerace (2009) advised, "[D]on't ask what the learning gain from [student response system] use is; ask what pedagogical approaches a [student response system] can aid or enable or magnify, and what the learning impacts of those various approaches are" (p. 147).

Penuel and colleagues (2007) similarly noted:

> Researchers who have studied student response systems in higher education share a belief that the technology alone cannot bring about improvements to student participation in class and achievement; rather, the technology must be used in conjunction with particular kinds of teaching strategies. (p. 318)

In keeping with this perspective, later sections of this white paper describe specific instructional uses of student response systems, including the research supporting those uses.

Student Response System Research and Insight 360

Insight 360 incorporates full capabilities of an effective student response system, including:

- Individual response pad for each student
- Capability to display questions for the entire class
- Instant results presented to the teacher in multiple formats (e.g., graphic format, numeric format) and available for display to the class
- Capability for immediate feedback to students
- Full integration with ExamView question banks, which are bundled with all major textbooks
- Reports of students' performance for teachers and administrators at the individual student, session, and class levels, including longitudinal data where appropriate

Research on Interactive Whiteboards (IWBs)

Research Findings

During the last ten years, a substantial body of research has been published examining outcomes and instructional patterns associated with the use of interactive whiteboards (IWBs). Because Insight 360 incorporates mobile interactive whiteboard technology, this research seems applicable to Insight 360.

Student Motivation and Engagement

One of the most common findings from this body of research has been an association between IWB use and improved student motivation and engagement. For example, the editors of a volume on IWBs published in 2010 stated that research to date on IWBs "seems to support the technology's potential to . . . increase attention spans and improve student focus . . . and develop 'theatrical tension' by captivating learners" (Thomas & Schmid, p. xx). A literature review in the same volume cited researchers who "present a strong evidential case for IWB as a means of capturing and sustaining student attention utilizing a wide variety of approaches, from written text to diagrams and the use of online websites" (Miller & Glover, 2010, p. 3, citing Kennewell & Beauchamp, 2007), and concluded that "Initial gains in the classroom are related to the presentational and motivational qualities inherent in the technology" (pp. 3-4).

Similar findings were reported by earlier reviews of the research literature. For example, according to Smith et al. (2005):

> The most widely claimed advantage of IWBs is that they motivate pupils because lessons are more enjoyable and interesting, resulting in improved attention and behaviour (see, e.g.[,] Beeland 2002). Pupils report that their lessons are faster paced, more fun and exciting (Levy 2002). The attributed cause of such engagement is varied and includes quality presentation (Becta 2003) incorporating large visual images (Smith 2000) with a more modern or contemporary feel which satisfy the expectations of pupils already immersed in a world of media images (Glover & Miller 2001; Beeland 2002). . . . Teachers too seem motivated by the boards and this influences pupils' perceptions (Cogill 2002). (p. 96)

Glover et al. (2005) linked student engagement with the improved content presentation capabilities of IWBs, stating: "Motivation is seen as a major gain from IWB use arising from the qualities of presentation and the use of colour, movement, and hide and reveal as spurs to participation and learning" (p. 162).

Interviews with a random sample of 68 teachers working with students 9-11 years old found that an "overwhelming majority (99%) believed that using the interactive whiteboard in lessons improved students' motivation to learn" (Higgins, 2010, p. 91). Group interviews with 72 students found that "students were very positive about the use of interactive whiteboards[;] they particularly liked the multimedia potential of the technology. . . . In particular, most of the student groups interviewed believed that . . . interactive whiteboard[s] helped them to pay better attention during lessons" (p. 91).

Student Achievement

Findings from IWB research to date have been mixed with respect to impact on student achievement (Miller & Glover, 2010, p. 8; Glover et al., 2005, p. 166; Smith et al., 2005, p. 91). In some cases, use of interactive whiteboards has been associated with improved student learning. For example, Miller and

Glover (2010) cited a 2006 study that "report[ed] positively on the impact of the technology in 40 out of 53 schools within one school district" (p. 8, citing Starkman, 2006).

Analyzing data from 100 classes with approximately 2,000 students, researchers in Great Britain found that "Multilevel modelling showed positive gains in literacy, mathematics and science for children aged 7 and 11, directly related to the length of time they had been taught with an interactive whiteboard (IWB)" (Lewin et al., 2008, p. 291). Students who had been using the IWBs for two years or more had greater achievement gains, compared to national norms.

A recent large-scale evaluation study involving 85 independent treatment/control comparisons, with data from more than 3,000 students in 50 schools across the United States, found a corrected overall percentile gain of 17% from use of IWBs (Marzano & Haystead, 2009, p. viii)[4]. Of the 85 individual comparisons, 26 were statistically significant in their own right[5]. 23 of these 26 statistically significant comparisons had a positive effect, while 3 had a negative effect (Marzano & Haystead, 2009, pp. 17-21).

Findings from this study also support a potential connection between student engagement using IWBs and achievement. Comparing the results of classroom observations of teachers whose students had positive achievement outcomes associated with the IWBs with results of classroom observations of teachers whose students had not achieved such results, they found that students in the classroom with positive achievement outcomes were more engaged[6], with engagement described as "students consistently attending to the activities orchestrated by the teacher" (Marzano & Haystead, 2009, p. 45). The researchers noted that "the central tendency for engagement was relatively high for both groups even though it was [significantly] higher… for the classes with positive results than it was for the classes with negative results" (p. 45)[7].

Content Presentation

Many of the instructional advantages of IWBs relate to their capabilities for presenting content information and concepts effectively, using multimedia and multiple sources (Glover et al., 2005, p. 162; Higgins et al., 2007, p. 215; Marzano, 2009, p. 81; Miller & Glover, 2010, pp. 3-4; Smith et al., 2005, p. 93). For example, Miller and Glover (2010) cited Kennewell and Beauchamp (2007) and Kennewell (2001) as suggesting the following:

> [T]he benefits of IWBs spring from their suitability for whole class teaching, their use in demonstrations and displaying concepts, and their consequent value in meeting the needs of a wide range of students through the varied presentation of ideas and the use of multimedia approaches. (p. 4)

Many researchers have linked these advantages of IWBs as a presentational technology to improved student engagement. For example, as noted above under Student Motivation and Engagement, Miller and Glover described "a strong evidential case for IWB use as a means of capturing and sustaining

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[4] Effect size = .44, $p < .0001$. Effect size units are standard deviations of the learning dependent variable, a useful metric for combining multiple studies. In education research, an effect size of 0.44 is generally considered to be a moderate effect—i.e., evidence that an intervention is of practical significance. Findings reported by Marzano & Haystead (2009) were corrected for attenuation due to lack of reliability in the dependent measure.

[5] $p \leq .05$.

[6] $p = .004$.

[7] $p < .01$.

student attention utilizing a wide variety of approaches, from written text to diagrams and the use of online websites" (p. 3; see also Glover et al., 2005, p. 162).

Findings from the Marzano Research Laboratory confirmed the importance of factors related to content presentation in helping to determine the effectiveness of IWBs. For example, Marzano (2009) found that "use of graphics and other visuals to represent information," such as "downloaded pictures and video clips from the Internet, sites such as Google Earth, and graphs and charts. . . . was . . . associated with a 26 percentile point gain in student achievement" (p. 80). At the same time, use of too many such visuals, so that "[d]igital flipchart pages were awash with visual stimuli [and] it was hard to identify the important content," was one of the characteristics of classrooms where teachers achieved better results *without* using IWBs (p. 81).

IWB Research and Insight 360

Insight 360 incorporates advantages of IWBs related to shared display and interaction, with all the capabilities of IWBs with respect to display of multimedia resources from a variety of sources. It is reasonable to infer that the benefits from use of interactive whiteboards with respect to student engagement and achievement apply to Insight 360 as well—particularly since options for display and projection with Insight 360 include interactive whiteboards.

At the same time, Insight 360's technology provides greater mobility for the teacher and greater opportunities for direct student interaction with the system, compared to standard IWBs. For more details, see the Promoting Student Interactivity and Engagement section later in this paper.

Value of Feedback

Research Findings

Based on their review of 250 research studies addressing formative assessment across multiple ages and subject areas, Black and Wiliam (1998b) stated, "Feedback has been shown to improve learning when it gives each pupil specific guidance on strengths and weaknesses" (1998b, p. 144). Specifically, they cited a meta-analysis of 58 experiments on " 'test-like events' (e.g., evaluation questions in programmed learning materials, review tests at the end of a block of teaching, etc.)" (1998a, p. 36, citing Bangert-Drowns, Kulik, Kulik, & Morgan, 1991), which found the following:

- "Feedback was most effective when it was designed to stimulate correction of errors through a thoughtful approach to them in relation to the original learning relevant to the task" (Black & Wiliam, 1998a, p. 36). Along similar lines, the authors of *How People Learn*—a synthesis of research on learning across the subject areas that incorporates findings from psychology, child development, the study of learning transfer, anthropology, and neuroscience—noted that "[f]eedback is most valuable when students have the opportunity to use it to revise their thinking as they are working on a unit or project"—in short, when the feedback is timely (National Research Council, 2000, p. 141, citing Barron et al., 1998; Black & Wiliam, 1998a; Vye et al., 1998).
- "[F]eedback was more effective when the feedback gave details of the correct answer, rather than simply indicating whether the student's answer was correct or incorrect" (Black & Wiliam, 1998a, p. 51).

- “[P]roviding feedback in the form of answers to the review questions was effective only when students could not ‘look forward’ to the answers before they had attempted to answer the questions themselves” (Black & Wiliam, 1998a, p. 51).

Controlling for the second and third bullets “eliminated almost all of the negative effect sizes that Bangert-Drowns *et al.* [1991] found, yielding a mean effect size across 30 studies of 0.58” (Black & Wiliam, 1998a, p. 51), which is generally considered among researchers to indicate an effect of practical significance. This speaks to the importance of teachers’ effective feedback techniques in their use of student response systems.

A review of 30 secondary-level peer-reviewed empirical research articles related to formative assessment published between 2000 and 2005 found similar positive effects for feedback. According to Tierney and Charland (2007):

> While these studies do not give indication of the relative merits of... different methods of feedback, positive consequences are generally seen. Feedback is described as an effective means of scaffolding learning... and encouraging greater student autonomy. (pp. 12-13)

Use of Insight 360 to Provide Feedback to Students

Insight 360 supports a seamless integration of formative assessment in a variety of formats and timely feedback to students during instruction. For example:

- Teachers can use the display to present formative assessment questions, problems, and assignments (including ExamView questions) simultaneously to the entire class or a group of students.
- Students can use the response pads to answer a variety of formative assessment question types (e.g., multiple choice, true-false, open response up to 140 characters). The teacher immediately sees the results of these assessments displayed on the touch screen on the teacher’s Mobi device, and can adjust instruction and provide feedback accordingly—without interrupting instruction by switching to another device or moving to another part of the room.
- Closed-ended questions can also be designed to provide immediate, focused feedback to individual students via the LCD screen on their response pads in response to the specific answer they gave.
- Individuals or groups of students can take turns using the Mobi devices to display their answers to open-ended formative assessment questions and assignments. These presentations in turn can be used as a springboard for whole-group discussion and further teaching.
- The display can be split into multiple sections for individuals or groups of students to simultaneously show their work on open-ended formative assessment questions and assignments. By monitoring the display, teachers can keep an eye on how students are doing in real-time, identify problems or misconceptions, and provide feedback and guidance as appropriate.

Addressing Student Preconceptions and Misconceptions

Research Findings

The importance of addressing student preconceptions and misconceptions is described in *How People Learn*. One of the "key findings" of *How People Learn* was that "[s]tudents come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom" (National Research Council, 2000, pp. 14-15).

Based on this finding, the authors recommended formative assessment as a strategy for "[t]eachers [to] draw out and work with the preexisting understandings that their students bring with them," stating: "The use of frequent formative assessment helps make students' thinking visible to themselves, their peers, and their teachers. This provides feedback that can guide modification and refinement in thinking" (p. 19).

Use of Insight 360 to Address Preconceptions and Misconceptions

Student response systems provide powerful tools for addressing student preconceptions and misconceptions. This is illustrated by the example of George Webb, an early practitioner who used such systems in a university physics class:

> [O]n introducing a new topic, he would often very carefully choose a question that had an obvious answer based on everyday nonphysicist thinking, but which was invalid. When over 90% of the class chose this answer and found out that they were all wrong, they suddenly became interested and were more than ready to listen to the first part of the lecture. (Abrahamson, 2006, p. 4)

Insight 360 facilitates the process of addressing student preconceptions and misconceptions by:

- Providing a means to frequently query all students mid-instruction
- Making responses simultaneous, so students can't be influenced by other students' responses
- Allowing responses to remain anonymous, so students aren't embarrassed by "wrong" answers
- Presenting the range and distribution of opinions in graphic format (e.g., through projected bar graphs and pie charts of student responses), which can be viewed by teachers and displayed to the class
- Providing a means for teachers to conduct reteaching that addresses specific preconceptions and misconceptions using engaging multimedia content

Modifying Teaching in Response to Formative Assessment Data

Research Findings

Black and Wiliam defined formative assessment as "all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged" (1998a, pp. 7-8). In their aforementioned review of 250 research studies related to formative assessment (Black and Wiliam, 1998a, 1998b), their general finding was that "innovations that include strengthening the practice of formative assessment produce significant and often substantial learning gains" (1998b, p. 140)—a level of gains they characterize as "quite considerable, and... amongst the largest ever reported for educational interventions" (1998a, p. 61)[8].

Formative assessment was particularly valuable for low-achieving students in the studies reviewed by Black and Wiliam. They found that "[w]hile formative assessment can help all pupils, it yields particularly good results with low achievers by concentrating on specific problems with their work and giving them a clear understanding of what is wrong and how to put it right" (pp. 142-143).

The value of formative assessment as a tool to guide instruction was similarly noted by the authors of *How People Learn*:

> Formative assessments—ongoing assessments designed to make students' thinking visible to both teachers and students—are essential. They permit the teacher to grasp the students' preconceptions, understand where the students are in the "developmental corridor" from informal to formal thinking, and design instruction accordingly. In the assessment-centered classroom environment, formative assessments help both teachers and students monitor progress. (National Research Council, 2000, p. 24)

A recent review of empirical research on formative assessment endorsed Black and Wiliam's findings, stating, "The teachers in many of these studies benefit from sustained support in learning how to use assessment to inform teaching" (Tierney & Charland, 2007, pp. 13-14). Specific positives mentioned by these researchers included

> the possibility of responding to the needs of an individual learner..., adjust unit plans... or shift curricular goals.... Assessment information provided by students can be "invaluable" (Nunes, 2004, p. 333) for teachers, and it can be used intentionally to improve the relevance and effectiveness of instruction (e.g., Vendlinski & Stevens, 2002). Improvements in student learning are linked to greater use of assessment information by teachers (Barootchi & Keshavarz, 2002; Dori, 2003), and improvements in student engagement are also suggested as teachers are able to "design future instructional strategies, materials and activities that are more meaningful and valuable to the learners" (Nunes, 2004, p. 333). (pp. 14-15)

Such information can be used to help teachers differentiate instruction. Leading experts on differentiating instruction recommend incorporating ongoing assessment by teachers as a key element in implementing differentiated instruction (Hall, 2002; Tomlinson, 2000).

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[8] Typical effect sizes ranged from 0.4 to 0.7 (1998b, p. 141).

Use of Insight 360 to Guide Adjustments to Teaching

More informed instruction on the part of teachers is one of the most frequently cited results of research studies on student response systems, and is a benefit noted by teachers in using such systems (Fies & Marshall, 2006; Penuel et al., 2007; Roschelle et al., 2004a, 2004b).

As noted above, Insight 360 facilitates frequent, timely formative assessment that can be used to guide adjustments to teaching. In particular, features of this system make it possible to take a quick snapshot of the understanding of *all* students in the class. This information is immediately available to guide instruction, without the need to wait for grading after class. Additionally:

- Information about individual student responses, accessible on the teacher's Mobi device and through system reports, provides information to teachers that can be used to differentiate instruction.
- Resources such as the ExamView question banks that accompany all major textbooks make it easy to incorporate questions that match the instructional focus of planned lessons.
- Longitudinal reports available through Insight 360 help teachers track student progress and make long-term plans to improve class-wide instruction and also support individual student needs.

Teacher Questioning

Research Findings

A synthesis of research related to teacher questioning found:

> Although some studies have produced conflicting findings, research strongly supports teachers' assumptions that asking questions contributes to the effectiveness of their instruction. Taken as a whole, studies conducted at all grade levels have indicated that both written and oral questions result in learning gains. (Ellis, 1993, pp. 2-3)

Gall and Rhody (1987, pp. 25-26) identified the following reasons that researchers have offered as to why questioning is effective:

1. Questions are motivating, and so they keep students on task.
2. Questions focus the student's attention on what is learned. A teacher's question is a cue to the student that the information required to answer the question is important.
3. Questions, especially thought questions, elicit depth of processing. Rather than reading the text passively, a good question requires the student to process the text actively and transform it into terms meaningful to him or her.
4. Questions activate metacognitive processes.... Thus, students become aware of how well they are mastering the curriculum content and whether they need to study it further.
5. Questions elicit further practice and rehearsal of the curriculum content.
6. If the student answers a question correctly, that is reinforcing, and the teacher may further reinforce the answer by praising or acknowledging it. If the student answers incorrectly, that can prompt the teachers to engage in reteaching.
7. Students' mastery of the curriculum is usually assessed by tests that consist of questions. Therefore, questions asked during instruction are consistent with the task requirement of tests.

Specific findings and recommendations related to effective questioning include the following:

- Different types of questions are appropriate for different instructional goals (Ellis, 1993, p. 3). For example, factual recall questions "have been found to be effective in reviewing material, assessing comprehension, and determining student preparedness" (p. 5). High-level "convergent" questions require students to "[look] for evidence to support, [give] reasons for behaviors or outcomes, and [draw] conclusions," prompting them to "extend their thinking by supporting assertions" (pp. 6-7). A third category, low-level "divergent" questions asking students "to think of alternate ways to do something," are suitable for use "as the first step in the problem-solving process or in a sequence of questions where students brainstorm possible solutions" (p. 7).
- Questioning should be frequent. Crooks (1988) summarized three research review essays as finding that "the frequency of teacher questioning has generally been shown to be positively related to student achievement" (p. 453).
- Questions should be directed toward, and answered by, "as many students as possible (to encourage all toward active learning)" (Crooks, 1988, pp. 453-454; see also Ellis, 1993, p. 12, citing Wilen, 1987; Black & Wiliam, 1998b, pp. 143-144).

Use of Insight 360 to Support Effective Teacher Questioning Strategies

Student response system functionality incorporated into Insight 360 is designed to support efficient simultaneous questioning of students, with the following capabilities:

- Students can use the individual response pads to answer multiple choice, multiple answer, yes/no, true/false, ranking, and advanced numeric questions, as well as open response items up to 140 characters.
- Individuals or groups of students can use the Mobi devices to demonstrate their answers to open-ended formative assessment questions and assignments.
- Questions can be set in advance or created spontaneously.
- Questions can be used to collect data of many different types, such as factual knowledge, opinions, predictions, evaluations, and higher-order thinking.
- Answers can be recorded for grading purposes or not, at the teacher's discretion.

Insight 360 is thus well suited to supporting frequent, unobtrusive questioning, using a variety of question types that can be answered simultaneously by all students.

Promoting Student Interactivity and Engagement

Research Findings

As noted previously, questioning is inherently motivating and focuses students' attention on learning (Gall & Rhody, 1987, pp. 25-26). In light of this, it is hardly surprising that improved student interest, motivation, and engagement are among the most common outcomes reported by studies of student response systems (Fies & Marshall, 2006; Kay & Knaack, 2009; Penuel et al., 2007; Roschelle et al., 2004a, 2004b).

Also as noted above, improved student motivation and engagement are among the key outcomes from research on interactive whiteboards. This is particularly the case when students are allowed to interact directly with the technology and when instruction is student-centered, as opposed to following a teacher-centered approach.

Direct Student Interaction with IWBs

Several researchers have found that IWBs are most valuable when students have opportunities to interact with them directly. For example, Lewin et al. (2008) found, "[E]ffects are greatest when [students] have the opportunity, individually or in small groups, for extended use of the IWB rather than as part of whole class teaching" (pp. 291-292).

Marzano and Haystead (2009) found significantly greater levels of multiple student use of the IWB (i.e., "many or all students in class coming to the front of the room and using the IWB in response to directions from the teacher") for comparisons showing a positive effect for IWB use than for comparisons showing a negative effect. They also found a statistically significant correlation between the corrected effect size for student achievement with IWBs and the variable of multiple student use of the IWB (p. 48)[9].

Similarly, in their review of research literature, Smith et al. (2005) found:

> The opportunity to use the board to present and discuss one's own work, or become involved with, e.g.[,] a class vote, is also acknowledged as likely to improve attention and engagement in the learning process (Bell 2001; Burden 2002; Miller & Glover 2002; Becta 2003). This is the reason Kennewell (2001) argues that pupils must be allowed to use IWBs themselves. (p. 96; see also Miller & Glover, 2010, p. 5)

Teacher-Centered Instruction and IWBs

Despite the benefits of IWBs, their use has also been associated in some cases with teacher-centered instructional methods that reduce active student involvement in instruction—generally considered a negative impact by educational researchers and theorists. According to Thomas and Schmid (2010), some studies "indicate that IWBs can be used to impede student control and reinforce the centrality of the teacher" (p. xx, citing Gray et al., 2007; Cutrim Schmid, 2008). Similarly, Lewin et al. (2008) wrote:

> [I]f teaching with IWBs is to work well, IWBs have to be used so that the full potential for them to act as a mediating artefact is realised. . . . If IWBs are used without this level of application, as glorified blackboards, or as occasionally animated passive whiteboards, then there will be little effect on pupils' learning. (p. 297)

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[9] This was a bivariate correlation of .430, $p < .001$.

Smith et al. (2005) analyzed the research on teacher-pupil interactions with IWBs as follows:

> [T]he IWB was felt by some teachers to enhance teacher-pupil interaction, “by encouraging students to offer answers to questions, which if correct can be noted on a flipchart” and was supported by . . . “the strong visual and conceptual appeal of the information and learning resources that are displayed” (Levy 2002, p. 8). The implicit structure of such lessons, however, is reminiscent of the pattern of interaction commonly encouraged in classroom[s] without IWBs: namely, the recitation script (Tharpe & Gallimore 1988). The recitation script has been criticised for limiting the possibilities for quality interaction by placing the teacher in the role of didactic expert and critical evaluator with the power to direct, question and evaluate students, whilst simultaneously removing power from students to ask as well as answer questions, and to evaluate their own and others’ understanding (e.g. Edwards & Westgate, 1994; Wood 1992). This pattern of questioning “seeks predictable correct answers and only rarely are teachers’ questions used to assist pupils to more complete or elaborated ideas” (Mroz et al. 2000, p. 2). (p. 95)

This remains a current challenge, as the following warning from a 2010 survey of IWB research literature attests:

> As a learning technology the IWB will only be of lasting significance in enhancing student attainment if teachers are prepared to change their teaching approaches to a more interactive mode. Without this change it is possible that the presentational advantages offered by IWBs will soon become commonplace and the potential for understanding and application will be lost, thus inhibiting progress in the long term. (Miller & Glover, 2010, p. 11, citing Smith et al., 2006; Greenfield, 2006)

Interactive Student Devices

Smith et al. (2005) specifically identified use of interactive student devices as a method to reduce the teacher-centered nature of the IWB classroom:

> The use of interactive “tablets” with an IWB in a primary school enabled one teacher “to be with the children rather than standing at the front doing the chalk-and-talk thing” (Walker [2002], p. 2). Greiffenhagen (2002) describes a school in Duisberg, Germany, which created a “computer-integrated classroom” by installing an IWB, which worked with several electronic tablets used by both teachers and pupils. This equipment largely removed the need for the teacher to stand in front of the class to manage the lesson. (p. 95)

Similarly, Higgins (2010) speculated that the “stage after this” in IWB use “is perhaps the development of multi-user, multi-touch environments . . . where networked multi-touch [devices] are the basis of a classroom environment supported with interactive technologies” (p. 96; see also Miller & Glover, 2010, pp. 8, 11).

Use of Insight 360 to Increase Student Engagement

Insight 360 incorporates a variety of resources to make classroom lessons more interactive, thereby raising student interest and engagement.

- As noted above, Insight 360 supports frequent teacher questioning of students during lessons. Students can be queried, not just for assessment purposes, but also to elicit opinions and provide anonymous classroom survey data as a basis for discussion.
- Questions can be displayed to the entire class. Student responses via the response pads can be tracked individually to encourage participation. Student responses are quick, silent, and largely unobtrusive, involving little disruption to the flow of class instruction.
- Students using the Mobi devices can show their work and interact directly with displayed instructional content, either individually or in small groups. For example, students might:
  - Show steps to solve a math problem
  - Interact with Google Maps during a geography lesson
  - Work through a physics simulation

  Instead of one student or a few students going to the front of the room to work on the IWB, the Insight 360 system allows input from up to four Mobi devices all over the classroom—an application similar to those described or envisioned by Smith et al. (2005), Higgins (2010), and Miller & Glover (2010).
- The Mobi 360 teacher device allows the teacher to direct instruction from anywhere in the classroom, freeing the teacher from a position at the front of the class.

Conclusion

Student response systems (SRS) and interactive whiteboard (IWB) technology represent important tools for improving K-12 instruction. Research on SRS suggests that they promote learning when coupled with appropriate pedagogical methodologies, including formative assessment; teacher questioning; addressing student preconceptions and misconceptions; focused, timely feedback; and adjustments to teaching informed by assessment results. Similarly, use of IWBs has been associated with improved student engagement, capabilities for presenting content information and concepts effectively using multimedia and multiple sources, and (in some cases) improved student learning. However, some researchers express concerns that use of standard IWB technology might promote teacher-centered instruction that reduces active student involvement in instruction.

eInstruction's Insight 360 system incorporates the capabilities of a student response system and mobile interactive whiteboard technology with integrated content as part of a complete mobile formative instruction system, a tool that enables teachers to improve student learning. In particular, Insight 360's integration of mobile technology taps the power of IWBs and SRSs while facilitating student-centered instruction and direct student interaction with these technologies. As such, it represents an effective next step in improving instruction through interactive classroom technology.

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