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IESD WHITE PAPER

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

Introduction

Over the last ten years, use of interactive whiteboards (IWBs) has become increasingly prevalent in K-12 education (Thomas & Schmid, 2010, p. xvii). Such systems provide increased capabilities for presenting and working with content in an integrated fashion, incorporating multimedia resources while facilitating whole-group discussion and student engagement (e.g., see Miller & Glover, 2010, pp. 3-4; Thomas & Schmid, 2010, p. xx).

Teachers have embraced this technology because it supports effective instructional practices and because they have seen positive benefits from its use. At the same time, the IWB has important limitations as an educational technology. While it is well suited to whole-class activities, with student attention and interactivity occurring toward the front of the classroom, the IWB is limited as a tool for small group cooperative/collaborative learning.

eInstruction's® Mobi™ mobile interactive whiteboard system represents a next step in the evolution of shared display and interaction technology that taps the power of IWBs while facilitating student-centered instruction and instruction in small groups. Furthermore, by utilizing the Mobi system with eInstruction's CPS™ student response system and the ExamView® assessment suite, teachers can combine this power with tools for effective ongoing formative assessment.

The purpose of this white paper is to summarize evidence related to effective instructional practices and to show how eInstruction's Mobi system can be used in research-based ways to support effective instruction. This paper draws on research related to:

- Interactive whiteboards
- Small-group, cooperative/collaborative learning
- Formative assessment

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:
  - Research on interactive whiteboards (IWBs)
  - Small group, cooperative/collaborative learning
  - Formative assessment
- Conclusion

Executive Summary

Research presented in the sections that follow supports the following key findings.

Interactive Whiteboards (IWBs)

- Many researchers of interactive whiteboards have found that this technology 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 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 (Lewin et al., 2008; Marzano, 2009; Marzano & Haystead, 2009; Miller & Glover, 2010). For example:
  - Multilevel statistical modeling based on data from 100 classes with approximately 2,000 students (ages 7 and 11) established that students who had been using IWBs for at least two years had superior achievement gains in literacy, mathematics and science, compared to national norms (Lewin et al., 2008, p. 291).
  - Evaluation research involving 85 independent treatment/control comparisons, with data from more than 3,000 students in 50 schools, found a corrected overall percentile gain of 17% from use of IWBs (effect size = .44, $p < .0001$) (Marzano & Haystead, 2009, p. viii).
  - More specifically, Marzano (2009) found that "use of graphics and other visuals to represent information . . . was . . . associated with a 26 percentile point gain in student achievement" (p. 80).
- Research suggests that IWBs may be most valuable when students have opportunities to interact with them directly (Lewin et al., 2008, pp. 291-292; Marzano & Haystead, 2009, p. 48; Miller & Glover, 2010, p. 5; Smith et al., 2005, p. 96).
  - For example, Marzano & Haystead (2009) found significantly greater levels of multiple direct student use of the IWB for statistical comparisons showing a positive effect for IWB use than for comparisons showing a negative effect. They also found a statistically significant bivariate correlation (.430, $p < .001$) between the corrected effect size for student achievement with IWBs and the variable of multiple direct student use of the IWB (p. 48).
- However, use of IWBs has also been associated in some cases with teacher-centered instructional methods that reduce active student involvement in instruction (Thomas & Schmid, 2010, p. xx; Smith et al., 2005, p. 95), particularly if teachers don't change their established instructional methods (Miller & Glover, 2010, p. 11).
- The Mobi system incorporates advantages of IWBs related to shared display and interaction, with all the capabilities of IWBs with respect to display of multi-source and multimedia resources. Mobi supports instructional uses of IWB technology that evidence suggests may be particularly effective. An important advantage of the Mobi system over standard IWBs is that Mobi's mobile interaction devices provide greater opportunities for student-centered instruction and direct student interaction with the system.

Small Group, Cooperative/Collaborative Learning

- Research evidence suggests that small group, cooperative/collaborative learning is an effective instructional strategy (Gillies, 2007, p. 25; Langer, 2001, p. 857; Slavin & Lake, 2008, p. 475). For example:
  - A meta-analysis identified a statistically significant effect size of 0.95 from use of cooperative learning strategies in science instruction with students in grades 5-8 (Schroeder et al., 2007, pp. 1436, 1450, 1458-1459).
  - In mathematics, a best-evidence synthesis found a median effect size across 9 studies of cooperative learning of +0.29 in the elementary grades (Slavin & Lake, 2008, p. 475).
- More specifically, research supports the effectiveness of using IWBs with small groups of students (Lewin et al., 2008, 291; Marzano & Haystead, 2009, pp. 56-57).
  - For example, Marzano & Haystead (2009) found a statistically significant bivariate correlation (.357, $p < .01$) between the corrected effect size for student achievement with IWBs and the variable of student interaction about the content—a variable that included a variety of group learning activities (pp. 56-57).
- However, there is evidence suggesting that use of standard IWBs may reduce the level of student small group work (Higgins et al., 2007, p. 220).
- Mobi's support of small group learning gives it an advantage over standard interactive whiteboard technology. Many of the models for implementing Mobi involve its use by small groups.

Formative Assessment

- Frequent formative assessment with timely feedback to students has value for improving both instruction and student learning (Black & Wiliam, 1998a, 1998b; Fies & Marshall, 2006; Hall, 2002; Kay & Knaack, 2009; National Research Council, 2000; Penuel et al., 2007; Roschelle et al., 2004a, 2004b; Tierney & Charland, 2007; Tomlinson, 2000).
  - For example, in a review of 250 research studies related to formative assessment, Black and Wiliam reported typical effect sizes ranging from 0.4 to 0.7—a level of gains they characterized as "amongst the largest ever reported for educational interventions" (1998a, p. 61; 1998b, p. 141).
- Mobi combined with eInstruction's CPS student response system and the ExamView assessment suite supports frequent formative assessment, timely feedback to students, and the ability for teachers to immediately see assessment results and adjust instruction in real-time.

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 Mobi is a mobile interactive whiteboard system, this research seems applicable to the Mobi system.

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 that interactive whiteboard 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 (effect size = .44[1], $p < .0001$) (Marzano & Haystead, 2009, p. viii). Of the 85 individual comparisons, 26 were statistically significant in their own right ($p \leq .05$). 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 ($p = .004$), 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 higher ($p < .01$) for the classes with positive results than it was for the classes with negative results" (p. 45).

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 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).

[1] 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 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).

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 bivariate correlation (.430, $p < .001$) between the corrected effect size for student achievement with IWBs and the variable of multiple student use of the IWB (p. 48).

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

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)

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)

IWB Research and the Mobi System

The Mobi system incorporates advantages of IWBs related to shared display and interaction, with all the capabilities of IWBs with respect to display of multi-source and multimedia resources. It is reasonable to infer that the benefits from use of interactive whiteboards with respect to student engagement and achievement apply to Mobi systems as well—particularly since options for display and projection with the Mobi system include interactive whiteboards.

At the same time, the Mobi system also provides greater opportunities for student-centered instruction and direct student interaction with the system, compared to standard IWBs. 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). Instead of one student or a few students going to the front of the room to touch the IWB, the Mobi system allows simultaneous input from up to nine Mobi devices all over the classroom. Practically speaking, this makes it much easier for students to interact directly with the technology. Models of effective use of the Mobi system move the focus of instruction from the front of the classroom to individuals or small groups of students working with the mobile devices.

Small Group, Cooperative/Collaborative Learning

Research Findings

Benefits from Small Group Cooperative/Collaborative Learning

According to Gillies (2007), research on cooperative learning in schools indicates that "There are academic and social benefits to working in cooperative groups" (p. 25).

Such benefits have been identified across multiple ages and subject areas. For example, a meta-analysis by Schroeder et al. (2007) identified a statistically significant effect size of 0.95[2] from use of cooperative learning strategies in science instruction, based on 3 studies of 641 students in grades 5-8 (pp. 1436, 1450, 1458-1459, citing Chang & Lederman, 1994; Houtz, 1995; Johnson et al., 1985). Cooperative learning strategies, in this context, were defined as follows: "Teachers arrang[ing] students in flexible groups to work on various tasks (e.g., conducting lab exercises, inquiry projects, discussions)" (p. 1446).

In mathematics, a best-evidence synthesis found that "the evidence supports various forms of cooperative learning. The median effect size across 9 studies of cooperative learning was +0.29 for elementary programs" (Slavin & Lake, 2008, p. 475).

In the area of literacy, a large-scale study comparing instructional practices in 14 middle schools and high schools that were performing better than expected on high-stakes assessments (based on their demographic data) with practices in 11 schools that were highly recommended but that were performing more typically on high-stakes literacy assessments found support for collaborative practices. One of six features that distinguished the high-performing from the typically performing schools was that in the high-performing schools, "Students work[ed] together to develop depth and complexity of understanding in interaction with others," while in the typical schools, "Students work[ed] alone, in groups, or with the teacher to get the work done, but [did] not engage in rich discussion of ideas" (Langer, 2001, p. 857).

Small Group Work and IWBs

Researchers have found that uses of IWBs with small groups of students can be an effective instructional model. For example, Lewin et al. (2008) found that "Where teachers had been teaching with an IWB for 2 years and there was evidence that all [children] had made exceptional progress in attainment in national tests, a key factor was the use of the IWB for skilled teaching of numeracy and literacy to pairs or threesomes of children" (p. 291).

Similarly, Marzano & Haystead (2009) found a statistically significant bivariate correlation (.357, $p < .01$) between the corrected effect size for student achievement with IWBs and the variable of student interaction about the content, which included "activities like: students answering questions in groups, students summarizing new content in groups, students making predictions in groups, etc." (pp. 56-57).

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[2] In education research, an effect size of 0.95 is generally considered to be a large effect.

At the same time, there is evidence that use of standard IWBs may actually decrease the prevalence of student small group work. Higgins et al. (2007), summarizing the results of a “large-scale evaluation of the impact of IWBs for the UK’s Primary National Strategy’s ‘Embedding ICT’ pilot project,” wrote:

> The project investigated the impact in terms of classroom interaction, reported in the study by Smith *et al.* (2006), where significant differences were found between lessons (n = 184) using IWBs and those not using. The IWB lessons contained more whole-class teaching and less group work, and this was true for both mathematics and literacy lessons. (p. 220)

Interactive small group work thus represents both an instructional opportunity and a potential area of weakness for standard IWBs.

Guidelines for Effective Small Group Work

Research provides guidelines for small group, cooperative/collaborative learning strategies that are likely to be effective with the Mobi system.

According to Gillies (2007), research suggests that cooperative learning groups should be small in size, “probably no more than 3-4 students” (p. 58). Such groups should also be well-structured (pp. 25, 58). Structured cooperative groups include the following characteristics:

- Positive interdependence among group members, meaning that “all members [work] together to complete the group’s goal” (p. 4).
- Promotive interaction: i.e., personal, face-to-face interactions in which group members “develop personal rapport that encourages students to be more willing to reach out to others, listen to what they have to say, and actively work to include others’ ideas” (p. 4)
- Individual accountability for contributions to the group (p. 5)
- Student use of interpersonal and small-group skills in areas such as communicating effectively, “shar[ing] resources fairly, tak[ing] turns, and engag[ing] in democratic decision making” (p. 5)
- Group processing: i.e., student reflection on “how they are managing the processes of learning” (p. 5)

In looking at the impact of small group learning with computer technology on individual achievement, a meta-analysis by Lou et al. (2001) found:

> Effect sizes were significantly more positive when specific cooperative learning strategies were employed (d_{+}= □□+0.21) than when students were generally encouraged to work together (d_{+}= □□−0.04) or when students in groups worked under individualistic goals or when no group learning strategy was described in the study (d_{+}= □□−0.08), with the latter two means not significantly different from zero. (p. 470)

Employing specific cooperative learning strategies was determined to be an important factor in the statistical model these authors developed to explain effective small group learning with computer technology[3]. This finding aligns with the research-based recommendation from Gillies (2007), cited above, that students in cooperative groups should utilize interpersonal and small-group skills (p. 5).

[3] This factor “accounted for a significant amount of variance in the hierarchical regression model” and was part of the optimal regression model (Lou et al., 2001, pp. 471, 472).

Lou et al. also found a significant impact from experience of group work over time and/or instruction in how to work in groups: “Effects of social context on student individual achievement were significantly more positive . . . when students had group work experience or instruction (d_{+}= +□□0.29) than when no such information was reported (d_{+}= □□□□+0.10)” (p. 470). Experience and/or instruction in working in groups was also determined to be an important factor in the authors’ statistical model for explaining effective small group learning with computer technology[4]. This aligns with the research-based recommendation of Gillies (2007) that “Teachers actively need to teach students how to interact socially in groups” (p. 216).

According to Gillies (2007), research also indicates that teachers should actively monitor students’ small group work and should provide them with appropriate constructive feedback (pp. 58, 216).

Use of the Mobi System to Facilitate Small Group, Cooperative/Collaborative Learning

The Mobi system has been specifically designed to support small group, cooperative/collaborative learning. Students working in groups may share up to 9 Mobi devices simultaneously—enough to accommodate a class of 36 students while adhering to the guideline from Gillies (2007) that cooperative learning groups should ideally not exceed 3-4 students. Alternatively, each student in a group of up to 9 students can use a Mobi device simultaneously, while other students in the class work on other activities. Both scenarios (one device per group, one device per group member) enhance opportunities for small-group work by making small groups more feasible, particularly in comparison with traditional IWB systems where only one student or a few students at most can use the display device simultaneously.

More specifically, the Mobi system can be used to support research-based guidelines for effective small group work, as described below.

- In cases where a class is divided into small groups (one device per group), typical Mobi implementations require groups to be well structured, with specific rules for contributing and interacting within groups. For example:
  - Sometimes each group member uses the Mobi to add a contribution.
  - Sometimes the group must come to consensus, with a chosen recorder entering the group’s response.
  - Sometimes group members check each other’s work.
  - Teachers may have students rotate roles within groups from time to time.
- Each group’s response can be displayed publicly, with the results becoming the stimulus for either large group discussion or additional small group work (e.g., where small groups pose problems during the first “round” and each small group tries to solve another group’s problem in a second round).

The implementation model described in the two bullets above promotes positive interdependence, promotive interactions, and use of interpersonal and small-group skills. It can also be used to facilitate reflection on group processing.

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[4] This factor accounted for a significant unique variance of 3.83% in a weighted least squares multiple regression (Lou et al., 2001, p. 471). It also accounted for a significant amount of variance in the hierarchical regression model and was part of the optimal regression model (pp. 471, 472).

The Mobi can also be used to help monitor student work in groups more effectively (see Formative Assessment below) and can thus be used to foster both positive interdependence and individual accountability. Student work/contributions are posted publicly, promoting group or individual accountability and allowing teachers to monitor progress and provide feedback and guidance as appropriate.

Formative Assessment

Research has confirmed the value of formative assessment as a means of providing feedback to students and modifying teaching to make it more responsive to specific student needs.

Research Findings

Value of Feedback

Based on their review of 250 research studies 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).

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)

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" (National Research Council, 2000, p. 141, citing Barron et al., 1998; Black & Wiliam, 1998a; Vye et al., 1998). In short, feedback is most valuable when it is timely and takes place during instruction.

Modifying Teaching in Response to Formative Assessment Data

Black and Wiliam defined as formative assessment "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 & 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), with typical effect sizes ranging from 0.4 to 0.7 (1998b, p. 141)—a level of gains they characterize as "quite considerable, and . . . amongst the largest ever reported for educational interventions" (1998a, p. 61).

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).

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 (Nunes, 2004) or a group (Thissen-Roe, et al. 2004), adjust unit plans (Hand & Prain, 2002) or shift curricular goals (Barootchi & Keshavarz, 2002; Dori, 2003)" (p. 14).

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)

In particular, 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).

Use of the Mobi System in Conjunction with CPS™ and ExamView® to Support Frequent Formative Assessment and Timely Feedback to Students

The Mobi and CPS™ systems, together with the ExamView® assessment suite, can be combined to support a seamless integration of formative assessment in a variety of formats and timely feedback to students during instruction. For example:

- Teachers can use the Mobi system to present formative assessment questions, problems, and assignments (including ExamView questions) simultaneously to the entire class or a group of students.
- Individuals or groups of students can take turns using the Mobi display to demonstrate 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 Mobi 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.
- Students can use the CPS response pads to answer closed-ended formative assessment questions (e.g., multiple choice, true-false) while viewing teacher instruction and informational resources displayed via the Mobi. The teacher immediately sees the results of these assessments displayed on the KWIK screen on the Mobi teacher 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 CPS response pads in response to the specific answer they gave.

- ExamView question banks provide closed-ended formative assessment resources aligned with all major textbooks that can be incorporated as part of lessons that take advantage of Mobi and CPS.

Teachers in a Mobi-plus-CPS classroom have immediate access to information about student understanding during instruction. This knowledge can be used to guide immediate feedback and adjust teaching as needed.

Kay and Knaack (2009) identified improvements to "the feedback cycle between instructor and students" as one of the benefits of student response systems in higher education (p. 383). In general, more informed instruction on the part of teachers is one of the most frequently cited outcomes of student response systems in research studies, and is a benefit noted by teachers in using such systems (Fies & Marshall, 2006; Penuel et al., 2007; Roschelle et al., 2004a, 2004b). Use of the CPS system in conjunction with Mobis makes these instructional benefits easily and flexibly available to K-12 educators as an integrated part of instruction.

Conclusion

Use of interactive whiteboards (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. eInstruction's mobile interactive whiteboard system, Mobi™, represents a next step in the evolution of shared display and interaction technology that taps the power of IWBs while facilitating student-centered instruction and direct student interaction with the technology. Mobi also provides substantial support for small group, cooperative/collaborative learning, an effective instructional strategy that may be underutilized in instruction with traditional IWBs. Additionally, in combination with the CPS student response system and ExamView assessment suite, the Mobi system supports frequent formative assessment with feedback—a valuable strategy that helps teachers improve student learning and modify teaching in response to student needs.

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