June | ‘11

Using New Technologies in Intermediate Classrooms Project Report

Martha J. Koch & Thomas Hillman

Report commissioned by the Ottawa Region MISA/PNC

Table of Contents

Introduction

In January 2011, the Ottawa Region Managing Information for Student Achievement Professional Network Centre (MISA PNC) commissioned this study to investigate teachers' use of new technologies in intermediate classrooms in two of their member school boards, the Ottawa Catholic School Board (OCSB) and the Renfrew County District School Board (RCDSB). More specifically, this study begins to explore the use of interactive whiteboard (IWB) technology (i.e. SMART Boards) in mathematics classrooms and the use of handheld computing devices (i.e. the iPod Touch) in various subject areas.

At this year's meeting of the Canadian Society for the Study of Education (CSSE) several presentations focused on the use of technology in K-12 classrooms. Two CSSE presentations were closely related to this study: researchers from Calgary described their study of the use of iPod Touch devices in Grades 6, 7, 8 and 12 classrooms (Crichton, Pegler, White & Onguko, 2011) and researchers from Alberta presented their findings on the use of IWB technology in schools (Brooks & Adams, 2011). These studies, which are further described in the literature review, highlight the increased interest across Canada in understanding the impact of these two technologies on student learning and classroom practice.

In this report, we provide an overview of recent literature on the use of these two technologies in classrooms, describe our data collection and analysis process, and summarize the observations we gathered. The data sources include: an online teacher questionnaire; classroom observation sessions and follow-up teacher interviews with two teachers using IWB technology; an Open Space Technology interactive session with a group of students taking Grade 9 Applied mathematics; and an interview with a secondary teacher who was using iPods in his classroom. The observations from these data sources are presented in two sections, one focused on teacher's perceptions and the other on student's perceptions. We then identify and discuss three key themes that emerged from these observations, make a few recommendations based on our findings, and suggest areas for continued research.

The research design for this project provides useful, valid and reliable observations about teachers' use of these two technologies in the two school boards. However, given the limited budget of $6000, this project is best viewed as a pilot study that could be the basis for a more extensive inquiry. In an effort to facilitate such an inquiry, copies of the research instruments have been provided as appendices to this report.

Before presenting our research, we want to acknowledge the support of the classroom teachers whose participation has made this project possible. While ethics guidelines require that our participants remain anonymous, we want to express our appreciation to those teachers who responded to the questionnaire, participated in interviews and invited us into their classrooms. Their willingness to share their experiences contributes enormously to better understanding the use of these technologies in intermediate classrooms.

A Review of Recent Literature

In this section we provide a review of some recent literature on the use of IWBs and iPod Touch devices in classroom settings. A list of references is provided at the end of the report.

I. Interactive Whiteboards

Developed and introduced to the market in the late 1990s, interactive whiteboards (IWBs) quickly made their way from the business settings they were initially marketed for to schools, colleges and universities. The potential for use of these electronic touch sensitive projection screens in classrooms has been particularly attractive to administrators in Canada, the UK and the US where investment in the technology has seen a dramatic increase since the early 2000s (Jewitt, Moss & Cardini, 2007; Kershner, Mercer, Warwick & Kleine Staarman, 2010; Mercer, Hennessy & Warwick, 2010; Smith, Higgins, Wall & Miller, 2005).

In these countries, it is now relatively common to find IWBs in classrooms across the spectrum of educational levels and subject areas. Despite the early enthusiasm for the technology, however, systematic inquiry into the effects of its introduction into schools and its pedagogical benefits has been slow to develop (Higgins, Beauchamp & Miller, 2007). Many researchers that made early attempts to determine the impact of IWBs on student achievement, for instance, struggled to find persuasive evidence of benefits (Smith, Higgins, Wall, & Miller, 2005). Studies such as that conducted by Glover and Miller (2001) showed that without investment in professional development for teachers, the affordances of IWBs did not become part of the daily practices in classrooms and thus did not have a significant influence on student learning.

Other studies indicate the potential of specific ways of using the technology such as moving back to previous screens to review material as questions emerge during lessons (Latham, 2002) and including interactive games in mathematics lessons (Edwards, Hartnell & Martin, 2002). This research also indicates, however, that without professional development and planning time where teachers could share techniques with each other, such beneficial patterns of use were relatively uncommon (Smith, Higgins, Wall & Miller, 2005). Supporting the finding that IWBs are a complex technology that teachers require time and help to effectively integrate into their practices, a long term study conducted in British primary schools suggests that only after two years with the technology in classrooms do significant changes in pedagogical practice develop (Somekh, Haldane, Jones, Lewin, Steadman & Scrimshaw et al 2007).

As IWBs have become an increasingly prevalent and established technology, researchers have begun to report on widespread patterns of use that effectively support learning and students' school achievement. Mercer, Hennessy and Warwick (2010), describe a number of technical IWB affordances and pedagogical practices that contribute to fostering the creation of rich dialogic spaces in classrooms. They highlight ten key affordances of the technology:

- drag and drop (objects on the board can be matched or moved around)
- hide and reveal (objects placed over others can be removed or an eraser can reveal hidden text)
- highlighting (transparent colour can be placed over writing or other objects)
- spotlighting (view restricted to circular area of screen)
- animation (objects can be rotated, enlarged, and set to move along a specified path)
- annotation of objects displayed (textual or graphical)
- tickertape (text moves continuously across screen)
- indefinite storage and quick retrieval of material, 'flipcharts' and annotations
- feedback (when a particular object is touched, a visual or aural response is generated)
- automatic handwriting recognition and text formatting features

(Mercer, Hennessy & Warwick, 2010 p. 197)

Mercer, Hennessy and Warwick (2010) found that when these affordances were used by teachers who had been encouraged to focus on finding ways of using the technology to promote dialogue in their classrooms, a space for reasoning and discussion was enacted that was richly multimodal including a wide variety of types of media and interaction. They note, "It is clear from our study that the IWB allows flexibility in the marshaling of resources that enables teachers to create interesting multimodal stimuli for whole-class dialogue much more easily than do other technologies" (p. 207).

In a similar study that examined the ways learning environments involving IWBs are orchestrated, Harlow, Cowie and Heazlewood (2010) observed and interviewed a primary school teacher in New Zealand that they felt effectively exploited the potential of the technology. They describe a variety of ways that IWBs can be used to help focus children's attention and guide them toward the development of learning skills. In particular, by letting students directly access the IWB as a way to contribute to a rich multimodal discourse, the authors found that the teacher orchestrated a learning environment where the technology encouraged active learning and helped students develop reasoning and communication skills.

II. iPod Touch Devices

Like IWBs, iPod Touch devices are a relatively new technology that was not initially intended for educational use but has made its way into schools. iPod Touch devices, however, are not nearly as widely used as IWBs in schools though many universities, particularly in the US, support their use for administrative and pedagogical purposes (e.g. Perkins & Saltsman, 2010). One reason for the limited use of iPod Touch devices in schools may be that the technology has radically changed since its introduction and it is only relatively recently that it has moved from being primarily a music-playing device to a multipurpose handheld computing device. The current generation of touch screen iPod and iPhone models bear little resemblance to the original iPod released by Apple Computer in the fall of 2001. While the original iPod was a major step forward in terms of portable music playing technology, its capabilities pale in comparison to the current generation that, through the downloading of applications (i.e. apps) and access to the

Internet, has an enormous range of functions from movie playing and gaming to mapping and blogging.

First introduced in 2006, the iPod Touch has attracted attention in the education community. Its touch screen interface and ability to run apps converge with the wider tradition of handheld computing devices used in schools and investigated in educational research (Banister, 2010). Particularly in mathematics education, devices such as Personal Data Assistants (PDAs) and graphing calculators have attracted a large research community and calculators are widely used in schools (Drijvers & Weigand, 2010; Roschelle, Kaput & Stroup, 2000; Tatar, Lin & Dickey, 2005; Trouche & Drijvers, 2010). Research on these devices suggests that particular affordances of handheld devices such as the portability that allows them to be easily shared can be of significant benefit in classroom settings (Drijvers & Trouche, 2008). Many characteristics of the iPod Touch such as its portability and flexibility in terms of pedagogical applications are similar to those found to be significant in research that examines the educational use of other handheld devices such as PDAs and graphing calculators. However, significantly less research has been conducted on the use of iPod Touch devices in schools.

Early researcher and practitioner writing about the use of iPods in educational contexts tends to be focused on such applications as having students create audio podcast presentations to share their work (Sprague & Pixely, 2008; Vess, 2006). This focus is likely due to the limitations of earlier iPods that were primarily music playing devices. The most recent research, however, has begun to discuss pedagogical applications that make use of the much broader functionality of iPod Touch and iPhone models (Banister, 2010; Hammond, Whatley, Ayres, & Gast, 2010; Kelly, 2011). For example, in a discussion of a New York program that uses iPod Touch devices to introduce basic kinematic concepts related to forces to elementary school students, Kelly (2011) describes how the touch screen and accelerometer interfaces of the device are well suited to giving students opportunities to explore Newton’s laws. In the program, students used nine different apps download from the iTunes App Store that involve working with forces in a variety of situations. While each app varied in terms of content and intuitiveness, overall the program was seen as successfully scaffolding students’ learning.

Similarly highlighting the pedagogical potential of iPod Touch devices, Banister (2010) draws on the broader handheld device and computing in education literature together with an analysis of the particular features of the iPod Touch to suggest a variety of teaching approaches for different subject areas. While making suggestions ranging from the use of the iPod Touch for map viewing in geography to graphing in mathematics and to access the Internet across subject areas, Banister notes that the educational use of the technology is still in its infancy and needs examination. He suggests that as teachers and researchers begin to make use of iPod Touch devices in wider numbers, the pedagogical potential of this flexible device will be uncovered.

A recent study conducted in a large urban school district in Calgary, AB examined the use of iPod Touch devices in five classrooms, Grade 6 (x2), Grade 7, Grade 8 and Grade 12 (Crichton et al., 2011). This two-year study began with an initial survey of teachers and information technology (IT) support staff to determine their familiarity with the device and the related iTunes environment. The researchers also participated in monthly professional development activities with the teachers, made regular classroom visits, conducted a post project online survey and conducted interviews with individual teachers and a selection of students.

Crichton et al. report that the IPod Touch devices were used in a sustained manner by the majority of participants in the elementary (Grade 6) and junior high settings (Grades 7 and 8). Participating teachers reported that the devices were particularly useful for students who were less successful in school because they felt that these students' level of engagement was improved. The high school students and teachers (Grade 12) were more critical of the devices and indicated that finding age and curriculum appropriate apps was a struggle. The authors note that it was vital for teachers to become familiar with the devices before using them in the classroom. Teachers needed to develop their ability to identify and download apps and to devise techniques for managing these processes with students before they began to use the devices in the classroom.

Crichton et al. also point out that in order to facilitate application sharing, each classroom needed to establish a "digital commons". Accordingly, in each classroom, a MacBook was the host computer for the shared iTunes account, apps were purchased through a common credit card and syncing devices were set up to overwrite any apps downloaded from students' personal computers. Students had to sync regularly to upload assignments, update apps and charge the units. Across the project, syncing issues proved to be the greatest source of aggravation. Infrastructure restrictions and personal information privacy regulations in the school district made the process of retrieving assignments from the devices particularly time consuming. In addition, administrators had to be prepared for students not following acceptable use policies and, in this sense, the devices introduced a new discipline concern. While the findings of this study are particularly instructive with regard to the range of issues that may be encountered in the deployment of iPod Touch devices in classrooms, the study provides less insight into the ways that this device supports students' learning, a topic that is in need of further research.

Data Collection & Analysis

In this section we provide a description of the processes we used to collect and analyse the data from the four data sources in the study. A summary of the observations from each data source is provided in a subsequent section.

I. Online Teacher Questionnaire

An online questionnaire was developed and administered to intermediate teachers in both school boards who had IWB's in their classrooms.

Item Development

The questionnaire items were intended to collect information about teacher demographics, usage habits, perceptions of student learning, implementation issues, and key supports. The questionnaire included eight selected-response items and seven constructed-response items and was hosted on fluidsurveys.com. The items were developed based on current research on the use of IWBs in classrooms as well as previous teacher questionnaires created by the researchers. Since the number of teachers invited to respond to the questionnaire was relatively small (total possible n=24), a relatively high proportion of constructed-response items was included to obtain more detailed information. Before being administered, the questionnaire items were reviewed by representatives of the teacher unions as required by one participating school board to ensure they were not evaluative in nature. The questionnaire items are included as Appendix A.

Questionnaire Administration

As a first step in administering the questionnaire, school board personnel at each board provided the researchers with a list of potential teacher participants. For the OCSB, the names and email addresses of teachers who were teaching Grade 9 Academic and Applied mathematics courses during the winter semester of 2011 was provided. For RCDSB, the names and email addresses for Grade 7 and 8 teachers with an IWB in their classroom was provided. The total number of participants invited was 24 (16 OCSB; 8 RCDSB). Each teacher was sent an email describing the research and inviting him or her to respond to the questionnaire. The email included a link to the survey as well as a password to ensure that only invited teachers would respond.

The questionnaire was available online from 11 Feb 2011 to 20 March 2011. In addition to the original invitation, two follow-up emails were sent to encourage teachers to respond to the questionnaire.

Description of Participants

Responses were received from 15 teachers (8 RCDSB; 7 OCSB) resulting in an overall response rate of 62.5%. The response rate for RCDSB was 100% and the response rate for OCSB was 43.8%. Accordingly, just over half of the teachers who responded teach mathematics at the Grades 7 and/or 8 levels. Of the Grade 9 mathematics teachers who participated, 57% were teaching only the Applied course, 14% were teaching only the Academic course and 29% were teaching both courses.

Data Analysis

Responses to all items are included as Appendix B. In our analysis of teachers' responses, we used descriptive statistics such as frequency distributions and percentages. From this analysis, three key themes emerged: characteristics of IWB use, perceived effects of IWBs on student learning, and support for teachers using IWBs. Observations for each of these themes are presented in a subsequent section.

II. Classroom Observations and Follow-up Teacher Interviews

While the questionnaire provides data about the general experience and perspectives of teachers across the two school boards, classroom observation and follow-up teacher interviews within each board provide more detailed information about various aspects of the use of IWBs in intermediate classrooms.

Data Collection

One classroom observation session of 75-90 minutes duration was conducted in each school board. To locate the classrooms for these observation sessions, we sent an email to all the teachers on the questionnaire contact list to ask for interested participants. Responses from two teachers were received promptly and observation visits were scheduled at the convenience of each teacher.

A classroom observation protocol was developed prior to conducting the observation sessions and is included as Appendix C. This protocol is based on classroom observation protocols we have used in previous studies but has been modified to include a more explicit focus on gathering information about the use of IWB technology in a classroom setting. We find that the use of an observation protocol improves the quality of the data collection process and is particularly beneficial when one or more research assistants are involved in collecting data for a project. Immediately after each classroom observation session, teachers were asked to participate in a brief follow-up interview that was audio-recorded. An interview protocol (see Appendix D) was developed for these interviews based on follow-up interview protocols we have used in previous research. The interview questions were reviewed by representatives of the teacher unions as required by one participating school board to ensure they were not evaluative in nature.

Description of Participants

In the OCSB, we conducted our observation session in a Grade 9 Applied Mathematics class shortly before the March Break. The teacher participant, who will be referred to using the pseudonym Rachel, has 7 years of teaching experience primarily teaching mathematics courses. In fact, for the past four semesters Rachel has exclusively taught Grade 9 Academic and Applied mathematics courses. At the time of our visit, Rachel was in her second year of teaching with an IWB in her classroom. In addition to the IWB, students in Rachel's class have the opportunity to participate in a home purchase plan for TI-Nspire Graphing Calculators and Rachel indicated that 80-90% of students in both her Academic and Applied mathematics classes currently own these devices.

In the RCDSB, we conducted our observation session in late May in a Grade 7 homeroom setting. The teacher participant, who will be referred to using the pseudonym Fiona, has over 20 years of teaching experience at the primary, junior and intermediate levels. At the time of our visit, Fiona was in her second year of teaching at the Grade 7 level and was in her first year teaching with an IWB in her classroom. In addition to the IWB, the students in Fiona's class were part of a pilot project and had been provided with individual netbooks for their use in the classroom and at home.

Data Analysis

The data sources from the OCSB observation session include the completed observation protocol, photos of the classroom, screen captures of the IWB lesson saved as a PDF file and a 28-minute audio recorded follow-up interview. The ability to store and retrieve entire IWB lessons was a process that Rachel frequently made use of in her program and was a feature that facilitated and enriched the data collection process for this study. The data sources from the RCDSB observation session include the completed observation protocol and a 19-minute audio recorded interview.

We began our analysis of the classroom observations and follow-up teacher interviews by reviewing the audio files for the interview and writing a summary of each teacher's response to each question. Selective transcription of some interview passages was conducted to provide quotations to illustrate key points. Our analysis of the classroom observation sessions began with writing a brief synopsis of each lesson. We then reviewed the completed observation protocols from each lesson as well as the other data sources to supplement and enrich the information provided in the teacher interviews.

The three general themes that were identified from our analysis of the questionnaire data (i.e. characteristics of IWB use, perceived effects of IWBs on student learning, and support for teachers using IWBs) have been used to organize and present the data from the classroom observations and follow-up teacher interviews.

III. Open Space Technology Session

In an effort to gather more data on students' experiences with the use of IWBs, we conducted an Open Space Technology session with the students from the Grade 9 Applied mathematics classroom in the OCSB where the observation session was conducted. Open Space Technology is a method that enables a group of participants to share their diverse perspectives. One advantage of this approach is that key issues emerge from the participants themselves rather than being suggested by the researchers. In addition, Open Space Technology is an active method of data collection that can engage students to a greater extent than a traditional focus group approach. Additional information regarding the use of Open Space Technology in research contexts is provided in Appendix E.

Data Collection

Both researchers conducted the Open Space Technology session during one 75-minute mathematics class approximately one month after the initial classroom observation session. There were 19 students present for this session. At the beginning of the session we described our research project through a brief PowerPoint presentation displayed on the IWB. We then directly engaged the students by conducting a brief survey using a classroom response or 'clicker' system. Each student was given a handheld device with nine buttons on it. We presented a series of questions to the class and asked them to select responses using the devices. The clicker system allowed us to capture the students' choices in real-time and to display the results after each question. In addition to being an efficient way to survey the class, by presenting the results after each question, the activity provided a starting point for the discussions that followed. Since few of the students had used a clicker system before, we began the activity by asking three practice questions. These questions which asked the students to choose their preferred snack food, the concert they would choose to attend, and the type of digital device they would choose if they could only have one, gave us the opportunity to introduce the clicker system and resolve any technical issues while the students became familiar with the device. Following the three practice questions, we presented a series of three prompts designed to provide insights into the students' usage and perceptions of IWBs. In addition, the prompts helped to orient the students' thinking for the Open Space part of the session. The clicker items and students' responses are included as Appendix F.

To begin the open space part of the session, we distributed a half-sheet of chart paper and a marker to each student. Students were asked to respond individually to the prompt "The thing I like best about having a SMART Board in math class is …" by writing some ideas on their chart paper. Students were then asked to post their response on the front wall of the classroom. In keeping with Open Space Technology methods, as a group we read through the various posted responses and students were invited to think about emerging themes or common ideas across the various responses. Next, students were asked to physically move their chart paper idea close to an idea that they felt was similar to their own idea. Once they had all had a chance to move their ideas around, we read and discussed the groups of ideas that were beginning to form. This process of reading and moving ideas was repeated twice and resulted in the formation of 5 self-selected groups of students, each focused on a somewhat different aspect of the use of IWBs in mathematics classrooms.

In the next phase of the session, we asked each self-selected group of students to move to separate areas of the classroom to discuss their ideas in greater depth. Each group was provided with chart paper and markers so that they could record the key points that came up in their discussion. Groups had approximately 10 minutes for discussion. During this time, the two researchers circulated from group to group to help groups stay on task and to prompt students to further elaborate the ideas they were recording on the chart paper. At the end of this period, each group was asked to share with the class some ideas that emerged during their group's discussion. Following this, students returned to their regular seats for a final question and answer session where they were given the opportunity to ask about any aspect of the research project.

Throughout the session, we emphasized the importance and value of being able to include students' perspectives in this research. The majority of students appeared very interested in contributing to the research as evidenced by their numerous insightful comments and thoughtful questions.

Data Analysis

The data sources from this session include the individual students' chart paper responses which initiated the session, the group chart paper responses that resulted from students' discussions, the researchers' observation notes, as well as students' responses to the selected-response items that were gathered using the "clicker" system (see Appendix F).

Analysis of the clicker responses was done using descriptive statistics including frequency counts and percentages. Analysis of the open space session data began with transcribing the individual and group chart paper responses (see Observations section). Frequently occurring comments were noted but we also highlight some less common but insightful comments that were made by individual students. Our observation notes were then reviewed to supplement and enrich the information provided by the chart paper and clicker responses. Two of the three themes used for the other data sources are relevant for this part of the study: characteristics of IWB use, and perceived effects of IWBs on student learning. These themes are explored in the Observation section.

IV. Use of iPods Teacher Focus Group/Interview

We had planned to hold a focus group interview with teachers using iPods in their classroom and to observe one class where iPods were being used. The names and email addresses for three teachers using iPods were provided to us by the OCSB. Invitations to participate in the research were sent to all three teachers. One teacher indicated that he did not have time to participate in the research, one teacher did not respond, and one teacher indicated he was interested in participating. Accordingly, rather than conducting a focus group interview, this aspect of the project was changed to an extended interview with one teacher.

Data Collection

The interview was based on the focus group protocol that is included as Appendix G. This protocol was developed to enable us to get a sense of teacher practices, the kinds of activities teachers are using the iPod for, other materials being used in conjunction with the iPod, the frequency of teacher and student use, the availability of support and resources for this technology, teachers' perceptions of the impact of the technology on student learning, as well as the role of teacher collaboration in the use of this technology. The 68-minute interview was conducted in April by one of the researchers and was audio-recorded to facilitate analysis.

Description of Participant

The teacher participant for the iPod Touch interview is referred to using the pseudonym Charles. At the time of the interview, Charles had over 30 years teaching experience at the secondary level. He is currently teaching in the contemporary studies department at a high school where he principally teaches law and politics at the grade 11 and 12 levels. Before moving to contemporary studies, Charles had worked as a technology teacher and considers computers to be one of his specialties.

As part of a pilot project initiated by the curriculum leader and a superintendent in the board, Charles has access to 15 iPod Touch devices. In addition to the iPod Touch devices, the school where Charles teaches had newly installed school-wide wireless Internet access. Two other teachers located in other schools participated in this pilot project. Charles indicated that they met at regular intervals over the school year to discuss their experiences with integrating this technology into their classroom practices.

Data Analysis

The interview was summarized and selectively transcribed as part of the analysis process. The three themes identified in our analysis of the other data sources (i.e. characteristics of use, perceived effects on student learning, and support for teachers) have been used to organize and present the observations from this interview.

Observations

In this section we provide a summary of our observations from each of the four data sources. Since we had the opportunity to hear both teachers' voices and students' voices in this study, we have organized our observations under these two categories.

I. Teachers' Perspectives

Observations from the IWB Online Teacher Questionnaire

Our analysis of teachers' responses to the questionnaire is presented in three areas of focus: characteristics of IWB use, perceived effects of IWBs on student learning and support for teachers using IWBs.

Characteristics of IWB Use

When asked how often they use an IWB the majority of teachers responded with either 'every class' or 'most classes'. Only 7% responded with occasionally and none reported never using the technology. Less clear, however, was the degree to which participants' exploit the unique dynamic and interactive features of IWBs. When asked to report which software they used with the technology, except for the *SMART Notebook*™ program required for operating a *SMART Technologies*™ IWB which all respondents use, the applications identified most were word processors closely followed by presentation software, video players, and web browsers. Each of these types of software were used by over 70% of respondents but, with the possible exception of web browsers that can be used to display interactive apps such as *Flash*™ based virtual-manipulatives, the software reported as most used is largely the same when displayed on an IWB as it is when simply projected on a screen. In addition, these widely used applications are not specifically intended for mathematical or mathematics education activities.

Participants did identify using mathematics specific applications such as statistical and graphing software but in each case less than one third made use of these tools. This pattern of use is also apparent from an analysis of the constructed-response items. When asked how they typically use IWBs during mathematics lessons, over two thirds of the statements made by the teachers described situations where they used an IWB to share information or demonstrate procedures to students and less than one third described students using the interactive features of the technology. Typifying this situation, one teacher noted, “I use it to take up work - use grids to show graphing....I also do a group note at the beginning to start the lesson... I would use it mostly as a chalkboard I think...”

Asked specifically to describe how their students typically use the IWB in their classrooms, several participants responded with descriptions of students exploiting dynamic and interactive features of the technology in combination with mathematics specific software but still two thirds of statements described student use of more static features such as writing solutions on the board. For instance, one teacher stated, “Students come up to write their solution to a homework question or an example.” Such statements and the selected-item responses indicate that the majority of teachers surveyed are not making significant use of the dynamic and interactive features afforded by the combination of an IWB and software for mathematics education. Most of the usage patterns discernable in the data could be achieved using the combination of a video projector and a traditional whiteboard or blackboard.

Perceived Effects of IWBs on Student Learning

Despite participants reported technical issues with IWBs, the clear majority of respondents characterized the effect of the technology on student learning in their classes as either entirely positive or mostly positive. Only 7% characterized the effect as somewhat positive and none felt that it was negative. Across the grade levels (Grades 7, 8, & 9) and streams (Academic & Applied) for this questionnaire, teachers described IWBs as being effective for supporting students’ understanding of concepts for all strands of the mathematics curriculum. Over 75% considered the technology to be effective for each strand of the curriculum with the exception of *Number Sense and Measurement* at the Grades 7 and 8 levels where 60% felt that is was effective. Asked to describe a specific instance where they felt the IWB was particularly effective in supporting student learning almost all the respondents gave an example. For instance, one participant offered:

> When one student shares their own solution to problems, we can shrink it - and have multiple students come up and demonstrate their math strategies. It is very powerful for students to see each other's work and see new and multiple ways of solving problems. They are very comfortable interacting with the Smartboard - using a wide variety of features, such as the grid paper background and other tools.

This type of response and the selected-response data clearly demonstrates the confidence the teachers have in the benefits of using IWBs during mathematics lessons.

The questionnaire also asked participants about their perceptions of the value of the IWB for differentiated instruction and as an assistive technology. Responses to this item were offered by 14 of the 15 participants and 79% of their comments clearly stated that they find the IWB helpful in differentiating instruction or as an assistive technology in the classroom. For instance, one teacher commented, "Yes. Students who are having more difficulty with a concept can benefit from Smart Tools or any sites that can be used interactively to help form/consolidate understanding."

Support for Teachers Using IWBs

Perhaps relevant to why comparatively few of the teachers surveyed reported exploiting the unique interactive and dynamic features of their IWB, many identified a lack of training and, crucially, a lack of time to explore the technology. One respondent noted, "I think I need to see more applications in use. I have lots of desire to try new things with the math but don't always have the time to find or learn about them." Another described a steep learning curve for using the technology and that it "takes many months to effectively prepare and present good lessons using the full functionality of the board and software."

Despite these statements, most respondents consider the support they have received for integrating IWBs into their practices to be either excellent or good. Only 27% characterized the supports they had received as only adequate or poor. When asked to indicate the kinds of support they received for using the IWB, the most frequently reported response was collaboration with colleagues with 87% of teachers indicating they had received this kind of support. Teachers offered additional comments that illustrate the value they place on collaboration with their colleagues such as "We learn together, as we go!" and "Snip-its with other teachers has been by far the most valuable." Board initiated professional development was the second most frequently selected form of support and was selected by 67% of teachers. The third most frequent form of support was technical support from the school board, which was selected by 53% of teachers.

The disparity between participants' assessment of the quality of support they have received and concerns about a lack of training and time for exploring the features of the technology suggests an issue in terms of the type of support offered. This issue can also be identified in participants' responses to survey items that asked them to describe problems or questions they have had with integrating IWBs into their practice and instances when they shared ways of using the technology with colleagues. Over 60% of the statements made by the teachers about problems or questions they have had and ways that they have shared practices with colleagues referred specifically to resolving technical issues. The remaining statements refer to a variety of issues such as pedagogical approaches or undefined general issues and sharing of practices. A typical response to what problems and questions participants have had is:

> This semester, the interactive whiteboard was not connecting properly with my laptop. So I had to use the programs through my computer instead. I spoke to a few colleagues and one mentioned how he used a different port on the computer and then it worked. I didn't have the problem last year so I was a little confused, but I was quite ecstatic when I could use the board properly with my students and their excitement grew as well.

Most responses to the question of how participants shared ways of using IWBs also focused on technical issues such as, “I am a 'go-to' person with regard to using interactive whiteboards in my classroom. I have helped colleagues with very basic needs (how to get the board working) to incorporating internet links.” These responses highlight participants’ focus on resolving technical issues when sharing strategies for using IWBs. This observation is understandable given the complexity of the technology that requires teachers to negotiate a variety of devices and software. It may also be related to the length of time that these teachers have had IWBs in their classrooms.

Observations from IWB Classroom Observations & Follow-up Teacher Interviews

Our analysis of the classroom observation sessions and follow-up teacher interviews in each board is presented in two ways. We begin by providing a synopsis of each observation session and then draw on the completed classroom observation protocols and teachers’ interview responses to address the key themes of this study (characteristics of IWB use, perceived effects of IWBs on student learning and support for teachers using IWBs).

OCSB Classroom Observation Synopsis

In mid March one researcher visited Rachel’s Grade 9 Applied mathematics classroom to observe her use of the IWB and talk with her about her experience integrating this technology into her program. On the afternoon of the observation session only 9 (3 female, 6 male) of Rachel’s 20 students were in attendance due to a field trip for another class as well as illness. Students were seated at individual desks arranged in five rows facing the front of the classroom where the IWB and projector were located. The lesson focused on graphing linear relationships, identifying strong and weak correlations and the concept of line of best fit.

To begin the lesson, Rachel led students through a brief activity where they matched graphs with descriptions of their characteristics on the IWB. In this activity the teacher revealed a graph by touching the IWB. She then asked students to match the graph with one description from each of three columns in the chart displayed on the IWB. Students raised their hands to respond and then came up to the IWB and used a drag and drop motion to match the graph with the appropriate descriptions. This activity, and the others in this lesson, were based on the TIPS Grade 9 Applied mathematics resource which had been adapted for use with the IWB by a team of teachers in the OCSB using *Flash*™ applications.

Students were then asked to turn to a specific page in their mathematics workbooks. The same page was displayed on the IWB. A number of sentences with missing words or blanks appeared on the page. Students were asked to fill in the blank verbally and Rachel used a reveal feature to show the correct word on the IWB after students responded. Students copied the correct word into their workbooks.

Using another *Flash*™ application, students were asked to match graphs to one of two spinning vortex images. The vortexes were labeled as positive and negative. Using a drag and drop motion on the IWB, students dropped each graph into one of the two spinning vortexes. If the graph matched the vortex chosen by the student it disappeared into the vortex but if the graph did not match the vortex it bounced back onto the screen. This is an example of the IWB feature which Mercer, Hennessy & Warwick (2010) refer to as feedback (see Review of Recent Literature, p.5).

Rachel then guided the students through a discussion of strong and weak correlations. Definitions of strong, moderate, weak and no correlation were displayed on the IWB along with graphs to illustrate each case. The same text appeared on a page in the students' workbooks. A key word was missing in each definition. Students were asked to fill in the blank verbally and then Rachel used a reveal feature to show the correct word on the IWB. Students copied the correct word into their notebooks. During this part of the lesson Rachel also used the IWB marker to draw bright red oval shapes around the collection of points on each graph as a means of emphasizing the degree of correlation. This is one of numerous examples that took place during this lesson of the use of the annotation feature of the IWB (Mercer, Hennessy & Warwick, 2010).

For the next 5 minutes students completed individual seat work in their workbooks where they looked at a series of graphs and decided on the degree of correlation present. Subsequently, the blank workbook pages were displayed on the IWB. For each graph displayed, a student was asked to come up to the IWB to drag and drop the correct label (i.e. strong, moderate, weak and no correlation) under each graph. In a classroom without an IWB, the same sort of "taking-up" activity could be conducted by having students state the correct answer but in this classroom the correct answer was communicated using the drag and drop motion on the IWB.

At this point in the lesson one student asked about non-linear relationships. Rachel used a blank sheet on the IWB to quickly draw an example of a non-linear relationship and then explained various aspects of the relationship. In a classroom without an IWB, the same sort of explanation and diagram could be provided using a blackboard/whiteboard. However, with the IWB Rachel could indefinitely store and retrieve the non-linear graph she had created.

The final activity during this lesson was “Creating a Line of Best Fit”. In this activity students were shown four rules for drawing a line of best fit on the IWB. They were then given rulers and asked to draw what they thought might be the line of best fit on a series of graphs in their workbooks. After approximately 5 minutes of individual student work, Rachel displayed the blank workbook page on the IWB. She used the IWB marker to draw a line of best fit on one of the graphs. She intentionally placed the line of best fit incorrectly and then moved the line back and forth over the collection of points to help students see where the line appeared to best fit. Rachel then explained to the class that in a subsequent lesson they would be using their TI Nspire graphing calculators to determine if they had actually found the line of best fit.

Towards the end of the lesson, two students who had been attending the field trip entered the classroom. Rachel indicated that she would email the lesson to these students and that she would post the responses to the various activities and workbook pages from this lesson on the class website so that the students could catch up on the work they had missed.

RCDSB Classroom Observation Synopsis

In late May one researcher visited Fiona’s Grade 7 classroom to observe her use of the IWB and talk with her about her experience integrating this technology into her program. On the morning of the observation session there were 22 students (8 female, 14 male) in attendance and the subject being taught was language arts. Student’s desks were arranged in a large rectangle such that students on three sides of the rectangle were facing the IWB and projector and students on one side of the rectangle had to turn around in order to see the IWB.

In previous classes, Fiona’s students had been working on writing travelogues using MS Word on their netbooks. The travelogues were to be posted on Blogmeister, a blogging engine developed for classroom use. During the observed class some students had completed their travelogues and were ready to share them with the class while others were still revising their writing. Fiona had intended to have students share their travelogues directly from the Blogmeister site but had been experiencing some difficulty accessing the site. Fiona indicated that the vice-principal typically troubleshoots technical difficulties of this nature but as he was unavailable at that time she asked students to email their MS Word documents to themselves and then had them use her computer which is connected to the IWB to open the document and share it with the class. The word document was visible on the IWB screen and four or five students in succession read their travelogues to the class. During this activity, student’s interaction with the IWB screen was limited to the use of the side scroll bar to move to the text at the bottom of the page. During transitions, as each presenting student emailed themselves their document and drew it up on the IWB, other students were given a few minutes to work on their own travelogues on their netbooks. Several times during the lesson Fiona had to prompt students to pay attention to the presentation rather than to their netbook screens. In one case she removed a student’s netbook and at another point in the lesson she asked all the students to turn their netbooks around so that they would not be distracted by their screens.

During much of this lesson, one student worked at the teacher's computer to help the students who were presenting their work access their travelogues on their web mail accounts and display them on the IWB. Fiona indicated that this student and one other student in her class were very skilled at solving technical issues with the IWB. One of these students indicated that he had used an IWB in his classroom since Grade 3 and the other had been using an IWB in his classroom since Grade 5.

During this observation session, many students were keen to share their views of the technology in use in their classroom. In their comments several students spoke of the netbook and IWB as though they were one technology. A number of students expressed their frustration with inappropriate use of the netbooks including downloading inappropriate games and software. One student indicated that the passwords for the netbooks were students' birthdates and were posted in the classroom. She noted that another student in the class had entered her password and downloaded inappropriate content on her netbook. This is one example of a number of comments made by the students and the teacher about concerns with the inappropriate use of the Internet in this classroom.

With specific reference to the IWB, the students emphasized two main benefits: being able to move things around on the IWB and having a large, bright display that all students in the classroom could easily see. While the lesson observed was not mathematics, both the students and the teacher spoke enthusiastically of using the National Library of Virtual Manipulatives website as well as SMART Board Math Tools on their netbooks and the on the IWB.

Characteristics of IWB Use

When asked about the role of technology in their classrooms, both Rachel and Fiona indicated that technology had become a central part of their teaching practice. In this section we summarize the key features of IWB use in these two classrooms including the software and peripheral hardware being used as well as the ways these teachers integrated the IWB into their lessons.

Over the course of two school years, Rachel has integrated the IWB, a laptop, a projector, a document camera, student owned TI Nspire devices, and a variety of software applications with a class website she has created. She spoke enthusiastically about the benefits of being able to save entire lessons, including the annotations and explanations that take place during a lesson, as pdf files that are posted to the class website for students and parents to access. She noted that these lessons can also be shared with supply teachers. Rachel finds these stored lessons much more beneficial than written lesson plans because they include documentation of what actually took place when the lesson was conducted. She has been teaching both Grade 9 Academic and Grade 9 Applied mathematics for four consecutive semesters and has found this method of storing and retrieving annotated lessons leads to faster and more effective planning. She states:

> It's [the IWB] changed my ability to be more clear with the students. I think I am more clear in expectations and in my explanations just because I can be very specific when I build the file . . . we've got these [Grade 9 Applied mathematics] SMART lessons pretty defined so it is actually saving me a lot of time.

Rachel noted that integrating the IWB lessons with the class website means that students who are absent can more easily catch up on missed lessons and all students have access to support materials while doing homework. In addition, this approach facilitates greater communication with parents who are able to access lessons on the class website. She summarizes her experience with the IWB when she states "I can't imagine not having it because there are so many things I have figured out are easier, once the learning curve declined".

In Fiona's classroom, both the IWB and student's netbooks were introduced at the beginning of the 2010-11 school year. Over the eight months that Fiona has been working with these two technologies, she has become more familiar with a variety of websites and software that are suitable for the Grade 7 curriculum and she has begun to incorporate these resources into her program. The aspect of these technologies that Fiona seems to find the most beneficial is that she and the students have access to the Internet. She states, "I am very pleased and happy to have the Internet at the tip of my fingers." For instance, students are encouraged to use the Internet to add "more interesting information to their writing". In addition, Fiona uses websites such as the National Library of Virtual Manipulatives and a website linked to the Nelson mathematics textbook regularly in her mathematics program. She noted that since the school invested considerable funds in technology, they had purchased very few manipulatives for use in the mathematics program. As she incorporates manipulatives into many aspects of her mathematics program, finding virtual manipulatives on the Internet was very helpful. Typically Fiona introduces a new virtual manipulative from this website on the IWB at the beginning of the lesson and then students access the same manipulative on their netbooks to continue to work with it. Fiona and two of the students in her class recounted their experience learning about tessellations and about integers using this approach. Fiona also noted that having the SMART Board Math Tools (e.g. protractor, ruler etc.) is very beneficial and enables her and her students to use the IWB in a more interactive manner. She states, ""It can be more than a projector and more than a blackboard if you have the interactive tools to go with it, otherwise it's just a whiteboard".

In Fiona's classroom there were a few signs that the process of integrating technologies into classroom practice was still at an early stage. In particular, Fiona and several of the Grade 7 students in her class commented on the ongoing struggle to ensure that students are using the technology appropriately. Thus, while Fiona describes her experience with technology by stating "It's excellent, I love it!" she also notes that "It has some extra class management and discipline problems because of the level of maturity of some of the students". She estimates that about 25% of the students in her class require constant monitoring to ensure that their use is appropriate even though the school has blocked students' access to many kinds of content.

In both the classrooms we observed the teachers described and demonstrated that they use the IWB at various stages of their lessons. Rachel and Fiona noted that the IWB could be used to introduce a lesson but is also very helpful for checking students' understanding in the midst of the lesson or at the end of the lesson. Both teachers found checking students' understanding of the material easier and faster with the IWB than when students are working on paper.

Perceived Effects of IWB on Student Learning

Both teachers believe use of the IWB enhances students' learning because it increases students' level of engagement and because the interactive affordances of the technology support the learning process. With regard to increased levels of engagement Rachel states "It's [the IWB] just so much better at making sure that they are with me". Similarly, Fiona states "I love that, they love that. It does engage them." Rachel also notes that the high quality resolution and larger size of the IWB screen keeps her students more engaged than a television screen would. Accordingly, even when the IWB is being used as a projector without engaging its interactive features, Rachel feels that it is more engaging for students than earlier projection technologies.

One affordance these teachers identified as enhancing students' learning is that students can move things around on the IWB. Both teachers spoke of the importance of students moving various objects around on the IWB, (e.g. lines on a graph, virtual manipulatives etc.), and of the way that this particular action can enhance students' mathematics understanding. In reference to using virtual manipulatives, Fiona states "They [students] find it very engaging and it helps their level of understanding". Rachel also valued that the students are looking at the same page in their workbooks that she is showing on the IWB. She states "It was so valuable to be able to be talking on the same page". Whether being used as a projector or for greater functionality, Rachel states that students are accustomed to the IWB as the location where they get their information "It's an environment that they are just used to. That's where they are used to getting their information." Thus, these teachers have the perception that the IWB enhances student learning both because it increases students' level of engagement and because specific affordances such as the ability to reveal and to drag-and-drop objects contributes to better understanding of mathematical concepts.

When asked about the value of the IWB for differentiating learning, both teachers think it is particularly beneficial for "low academic" or Applied students. Rachel says "I do it so much more effectively with my Applied than my Academic . . . I have done a much better job of getting them [students in Applied course] interactive." She attributes this success with the Applied course to three things: the nature of the Applied curriculum as compared with the Academic curriculum, the availability of resources for IWB for the Applied course and characteristics of the students in her Applied courses. She explains that her success integrating the technology in her Applied course is "Partially because some of that has been created for me and partially because the TIPS format is just so rich in experiential things whereas in Academic you tend to fall more into a chalk and talk because of the volume of information you have got to get out". But she also sees differences in the students themselves and has found students in Academic course less inclined to go up to the front of the classroom to use the IWB.

She states “They [students in the Academic course] want time to process on their own” but also indicates that she is gradually getting these students more interested in using the IWB.

It is interesting to note that Rachel uses the various pieces of integrated technology in her classroom differently in the Grade 9 Applied course than she does in the Grade 9 Academic course. For instance she explained that in the Applied course she introduces graphing “with technology” (i.e. using graphing calculators) after the students have learned to do graphing with pencil and paper whereas in the Academic course graphing “with technology” is done before they are asked to do graphing with pencil and paper. This observation suggests that teachers may develop a variety of pedagogical approaches as they integrate the IWB with other forms of technology to implement the curriculum.

Fiona also expressed the view that the IWB was particularly beneficial for students who were not as strong academically. However, she also seems to hold some conflicting views - while she believes that the lower academic students tend to be more engaged in their learning when using the IWB and netbooks, she also finds that they are more likely to use the netbook for gaming and to require closer supervision. Fiona summarizes the impact on learning by describing the IWB as an “excellent tool for those who use is appropriately . . . it enhances their work and their knowledge.”

Support for Teachers Using IWBs

When asked about the resources and supports they found helpful as they began to use the IWB, Rachel and Fiona each identified a number of sources of support as well as some key characteristics of the support they need.

Rachel identified several sources of support and then described a key characteristic of support for IWB use. Rachel had participated in several professional development opportunities provided by the OCSB that she found helpful. In particular, in the previous summer she had taken part in a board initiative to write lessons for the IWB. In this initiative, Rachel began with basic lessons she had already been using with the IWB and learned how to enhanced them in a variety of ways including colour coding series of slides and embedding links. She noted that during this summer writing program each teacher worked with a partner, an approach she found beneficial. She states, the summer program “Exponentially changed my understanding of how it works and what I could do with it”.

Another ongoing source of support Rachel identified was working with her colleagues. She noted that in her school there were four teachers all learning to use the IWB at the same time. Sometimes one of the teachers figured out something new and then shared it with the others. She states: “Because we were all in the same boat of trial by fire, we were very happy when someone would walk in and say “look at what I can do”, “look how easy this is” or “I just found this short cut” or “did you know” and because we were all doing it at the same time, it was so nice to have.” Rachel also commented that students are a source of support both in troubleshooting technical issues and in showing teachers additional features of the IWB technology.

A key characteristic of effective support that Rachel identified is that at every training session she attends she learns one or two new “tricks” but finds she needs time to absorb each trick. She characterizes effective support by stating:

> I need to be able to use it, one or two things and use them before I get one or two more things because you can be inundated with things that you can do but unless you can actually personally incorporate them you don’t remember them and then they become useless skills instead of useful ones.

Her comment speaks to the value of relatively brief but ongoing and incremental support for teachers as they incorporate this complex technology into their practice.

Fiona indicated that she had taken IWB workshops from time to time for a few years before she had an IWB in her classroom and these workshops had given her a sense of the features of this technology. More recently, she has found the board consultant who comes into her classroom to demonstrate various features and software applications to be very beneficial. Fiona notes that the consultant at times works with individual teachers, at times with a group of teachers and at times with the students in her class.

Like Rachel, but to an even greater extent, Fiona has found that her students are a valuable resource. She finds that they are very quick to learn about IWB technology and they are often able to show her how to resolve technical problems. Fiona’s greater reliance on students than Rachel may be in part due to the fact that many of her Grade 7 students have been using an IWB since Grade 3 and have accumulated considerable knowledge about this technology. In contrast, most of the Grade 9 students in Rachel’s class had only had access to an IWB for a year or two. Nonetheless, in both classrooms it seems that the entire classroom community becomes involved in successfully using this complex technology.

While Rachel explicitly identified her colleagues as one of the most significant forms of support in learning to use the IWB, Fiona only mentioned her colleagues when asked directly about the extent and benefit of exchanging ideas with other teachers in her school. While Fiona did indicate that the teachers in her school share interesting IWB resources when they find them, her description suggests that this was not a key form of support. The decreased emphasis on colleagues as compared with Rachel, and with the responses on the teacher questionnaire may be due to the fact that the teachers at Fiona’s school are working together this year for the first time in a newly created Grade 7 and 8 program. Thus, these teachers may not have had an opportunity to establish working relationships with one another.

Like Rachel, Fiona also offered an interesting observation about the kinds of support she finds most valuable. She states “I like to go to something that’s already done and I can use it and it’s interactive already . . . instead of inventing the wheel”. Fiona’s comment is strikingly similar to

Rachel's experience with using the Grade 9 Applied mathematics lessons for the IWB that are based on the TIPS document. These ready-made lessons include numerous interactive IWB activities that are linked to students' workbooks and have become the mainstay of Rachel's mathematics program. Indeed, having access to ready-made resources for the IWB is one of the reasons Rachel offers for integrating the IWB so much more successfully in her Grade 9 Applied mathematics program than in her Academic program.

One additional source of support that was mentioned by both teachers as key in helping them incorporate the IWB into their practice was the availability of time to explore the features of the IWB and to locate suitable websites and curriculum specific resources. Rachel felt that she had had adequate time over the 18 month period that she had been using this technology but Fiona expressed the need for more time to become familiar with this technology.

The classroom observations and teacher interviews suggest five sources of support for the use of IWB's are particularly beneficial: board consultants and PD workshops, working with colleagues, students, ready-made IWB resource materials linked to the curriculum and time to explore the technology. In addition, one characteristic of effective support was clearly identified; ongoing, shorter professional development sessions where only a few new features are introduced at a time.

Observations from the iPod Teacher Interview

The observations from the iPod teacher interview are presented in the same areas of focus used for the teacher questionnaire and classroom observations: characteristics of use, perceived effects on student learning, and support for teachers using iPod Touch devices in the classroom.

Characteristics of iPod Touch Use

Seeking to access the wide range of online resources related to geography without moving to a computer lab, Charles turned to Apple's iPod Touch. While he had intended to use iPods with his entire Grade 9 Academic Geography class, Charles found that implementing and managing the technology was impractical with such a large group. Seeking to try the iPod Touch with a smaller group, he chose instead to work with 17 students who were enrolled in essentials and workplace courses. The group included a number of students who were identified as being Mildly Intellectually Disabled (MID). Charles indicated that this group of students were excited to use the technology and motivated to participate in the trial despite early technical issues such as connecting with the school's newly established wireless network.

Later in the semester, Charles began to use the iPod Touch devices with his Grade 12 Law class as a means of accessing legal documents and in a parenting class using YouTube videos and apps that simulate babies. Despite these effective uses, he indicated that in general he did not find many apps that were particularly useful and the majority of time with the devices was spent accessing websites. Charles also tried connecting iPods to the IWB in his classroom but since he was only able to project video and was not able to use the interactive features of the IWB he did not find the combination of technologies particularly useful. This was unexpected since Charles had specifically requested funding for the iPods as devices for students to use in concert with the new IWB in his classroom.

Using the 15 available iPod Touch devices, Charles often directed his students to access a particular website during a class. This usually involved displaying a worksheet or activity description on the IWB that contained addresses for specific sites useful or necessary for completing a task. Since Charles found it important to connect work on individual iPods to the rest of the class, he asked students to share their work by emailing notes from the devices to him so that he could share them with the class on the IWB. These notes most often included pieces of text and links to resources on the Internet that Charles then accessed on the IWB.

While the connections between the iPod Touch and the IWB were not as rich as Charles had hoped, he did find the devices useful in his Grade 12 Law class where students could use them to access documents such as the Canadian Charter of Rights and Freedoms. In this class, however, a major issue was the number of students. With 34 students and only 15 iPod Touch devices available, Charles relied on the fact that a large number of his students owned their own devices that could wirelessly connect to the Internet. These student-owned devices supplemented the school-owned iPods but presented challenges in terms of the different compatibilities and affordances of each device. Charles expressed the view that these challenges were worth overcoming since sharing iPods proved impractical. In addition, he saw students using their own devices as advantageous in terms of privacy issues. Since iPods are designed as personal devices for use by individuals and not as devices to be shared, a number of technical challenges emerged. Each time a session with the devices was finished, Charles had to remind students to go through a systematic process of erasing passwords and clearing preferences to ensure that the next user could not access the previous users personal accounts such as email and Facebook. For students who owned their own devices, this procedure was not necessary. In addition, school-owned iPods needed to be distributed at the beginning of every class and accounted for at the end. The participant estimated that these kinds of logistical tasks took 10-15% of class time but also noted that this loss of time was not dissimilar to the time needed to move a class to a computer lab. Charles summarizes his use of the iPod Touch device by stating:

> All in all, for anything that's text dependent, either paper or digital, it's [iPod] limited as to its usefulness I find . . .[Its good for] reading maps and graphs and accessing those kinds of things but if you want to manipulate it then you've got to make this bridge over to existing forms of digital equipment, I guess that, I guess the translation probably is the biggest negative.

Based on his experience with this iPod Touch pilot project, Charles suggested that netbooks would perhaps be a more appropriate technology for classroom use. He noted that the small screen size and lack of word processing features on iPod Touch devices renders them less than ideal for classroom settings but netbooks, which he saw as being similar in cost to iPods, better serve these needs. He states, “If we went with a department set of something, I think it would probably be netbooks. And that’s what I’ve recommended to my VP.”

<u>Perceived Effects of iPod Touch Devices on Student Learning</u>

Charles described that the ease of access to resources like atlases that the iPod offers is of benefit to his students’ learning. Also, he felt that the technology made it possible for him to teach his students how to use the Internet for learning and to help them develop their thinking skills. Using the example of websites dedicated to weather mapping and forecasting, he noted that the iPod Touch devices afforded students much greater exposure to information than a textbook could provide. Charles cautioned, however, that teachers should plan activities rather than letting students freely roam the Internet and that they should be aware that students might have some difficulty translating between visual content on the small screen of the iPod and in other media such as textbooks. In addition, a negative feature of the technology may be the time it takes to solve technical issues that can take away from the time available to work with content. Particularly since the screen of the iPods could not be shared using the IWB in the classroom, Charles sometimes found it difficult to guide students through particular activities and to keep them on task.

Talking about the ways students used the iPods, Charles indicated that it had forced him to challenge his own notions of how much information it is necessary for students to know. He realized that when students have wireless access to the Internet they don’t necessarily need to have memorized information that they can get through their iPods. This realization changed the focus of Charles’ assessment practice and inclined him to emphasize making connections rather than testing things like the recall of terminology.

With regard to the use of this technology to differentiate teaching and learning experiences, Charles indicated that most of the students identified as needing assistive technology in his school already have access to laptops and would not need to use the iPods. In addition, he described how the small screen and touch interface of the iPods were a challenge for one of his students who lacked the fine motor skills necessary to operate them. Accordingly, while the rest of the class worked with the iPods, this student worked with a laptop.

At the same time, Charles found that the students who benefited most from using the iPods were those that had limited access to the Internet at home and those that were struggling with their courses. Charles felt that these students would have benefited from being given an iPod to use outside class but again suspected that a technology like netbooks that students can, for instance, print from may be more appropriate.

<u>Support for Teachers Using iPod Touch Devices</u>

A curriculum leader along with a superintendent in the OCSB who both focus on technology integration initiated the iPod Touch pilot project that Charles participated in. Beyond that leadership support, another major factor that supported the introduction of the iPods was the installation of school-wide wireless networking. In addition, two other teachers located in other schools participated in the pilot project and all three teachers met to discuss integrating the technology in their practices. Much of the discussion between these teachers revolved around trouble shooting issues such as charging 15 iPods at a time and making best use of available battery time. The teachers were expected to document their experiences and make a report. A review of this report, when available, would enrich the findings of this study.

II. Students' Perspectives

In addition to gathering information about teachers' experiences with the IWB and iPod Touch devices, we were able to gather some information about students' perspectives of the IWB technology. In this section we summarize our observations from the clicker response activity as well as from the Open Space Technology session. We present our analysis of these observations with regard to two of the three key themes in the study, characteristics of IWB use and perceived effects of IWBs on students' learning. The third key theme, support for teachers, is not addressed as it is not typically a part of students' experience.

Observations from the Classroom Response Clicker Activity

When asked to select which of their classes had included IWB use, 63% of the students indicated that the technology had been present in their classes in several subjects while the remaining 37% indicated that they had only encountered IWBs in mathematics classes. This result was also confirmed in the discussion that followed where relatively few students described having used IWBs in earlier grades but several discussed their presence in other Grade 9 classes, particularly in science. Despite some students speaking about the use of IWBs in other classes, both the discussion and the survey item suggest that for these students, mathematics is the primary subject where they encounter this technology.

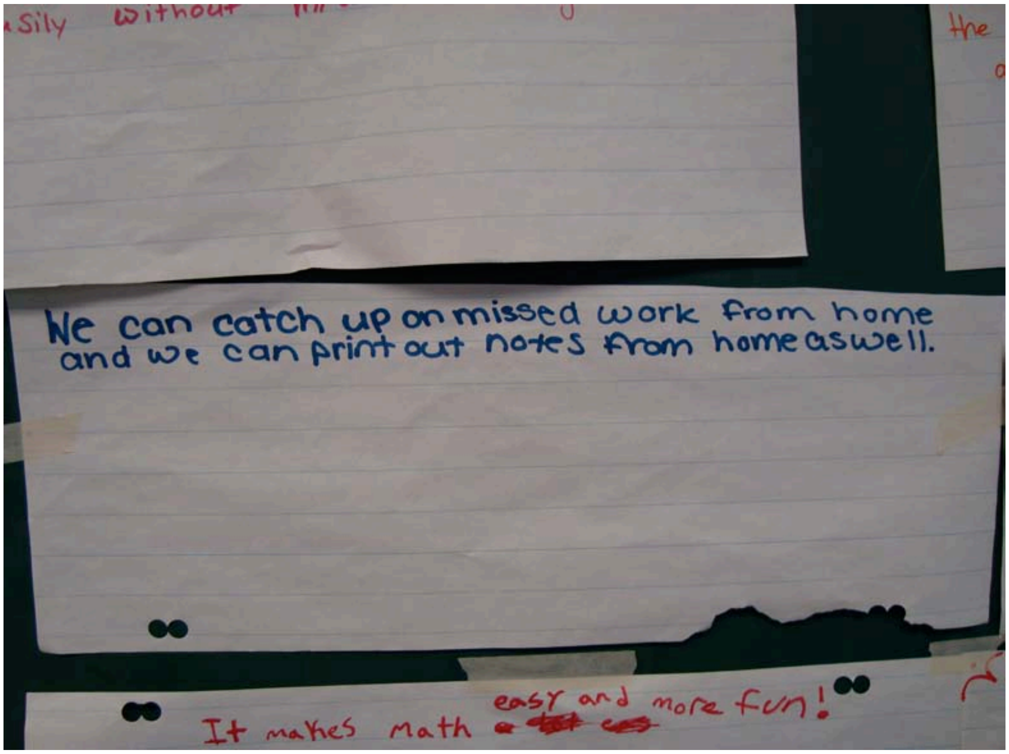
Thinking specifically about their Grade 9 mathematics class, we asked the students to consider the prompt "I feel the SMART Board has… ". Students had four response options: helped my math learning, made my math learning more difficult, had no impact on my math learning and not sure/no opinion. In response to this item, 58% indicated that IWB use had helped their mathematics learning while 21% felt that it had no impact, 11% were not sure, and the remaining 11% felt that the IWB had hindered their learning. While only slightly more than half the students indicated that IWB use had helped their mathematical learning, when asked if the technology should be in all mathematics classrooms the overwhelming majority (85%) responded with either strongly agree or agree. Only one student indicated that he disagreed that all classrooms should have IWBs and in the discussion that followed he commented that he had selected 'strongly disagree' just to see what would happen on the clicker system. The disparity between students' opinions on whether or not IWB use had helped their learning and whether or not they should be installed in all classrooms suggests that while the students appreciate the technology and value its features, they do not necessarily consider its use to relate to their learning. This may speak to the ways the technology is used and indicate that, from the students' perspective, it is not always used in ways that support their learning.

Observations from the Open Space Technology Session

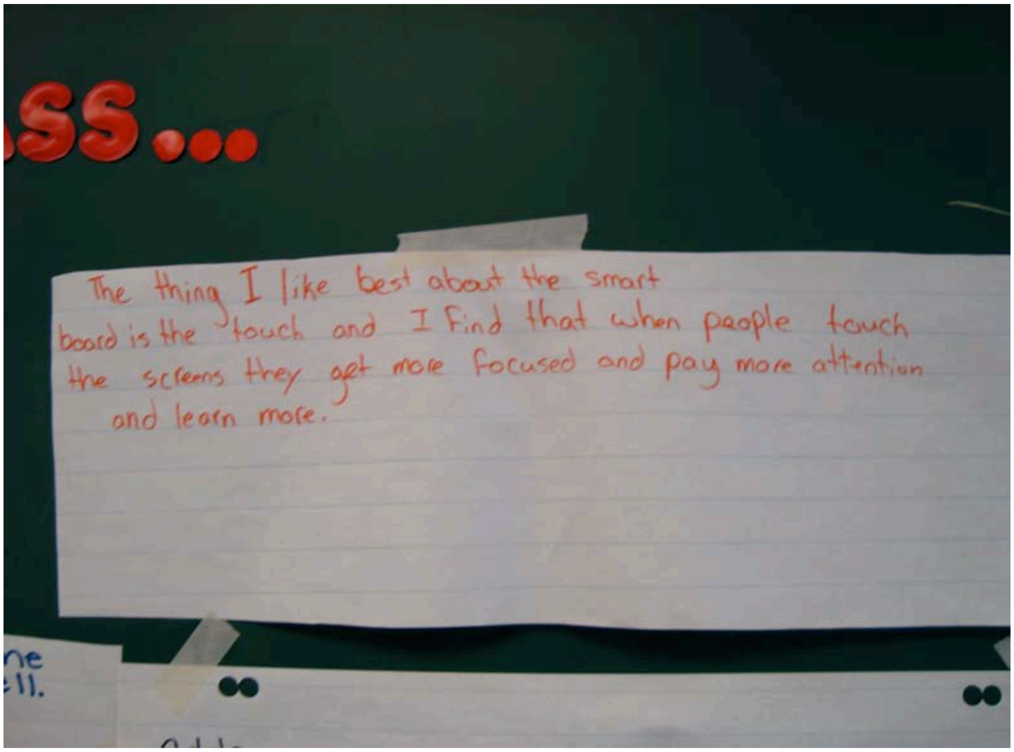
In the first phase of the open space session students were asked to respond individually to the prompt "The thing I like best about having a SMART Board in math class is …" by writing on a piece of chart paper. The responses of each of the students are shown in the table below.

1	I like that my teacher can take what we learned that day on the smart board & put it on the site, so you can keep up when your away! Plus more interaction.
2	We can catch up on missed work form home and we can print out notes from home as well.
3	Getting to play games to help me understand the math.
4	easy to use and help's me learn better has very accurate answers and it is very easy to read off of it.
5	It makes math easy and more fun!
6	there is a lot more that can be done on a smartboard than a chalkboard and it's very organized which makes it easier to learn
7	Easier to learn with it.
8	The Smart Board is interactive, so you can play games in class and give demenstrations [sic].
9	It's interactive and a great and fun way to learn math easily without misunderstanding the lesson.
10	That everything your going to learn is set up (Almost all the things) And Its easier to finish everything in class Then Homework 24/7.
11	I like going up and actually using the smart board while doing math!
12	The thing I like best about the smart board is the touch and I find that when people touch the screens they get more focused and pay more attention and learn more.
13	Is good I like to write and use for math and science.
14	I like that we can actually interact in the lesson and that COOL pictures are used in the lesson.
15	Adds an element of amusment[sic] to the class, because we can all interact with it, and do thing we wouldn't be able to do on a chalkboard, whiteboard or overhead.
16	I like SMART Boards !!
17	We get more involved & we get to do more hands on work.
18	Its hands on.
19	I like smart board in math class because I don't have to write stuff.

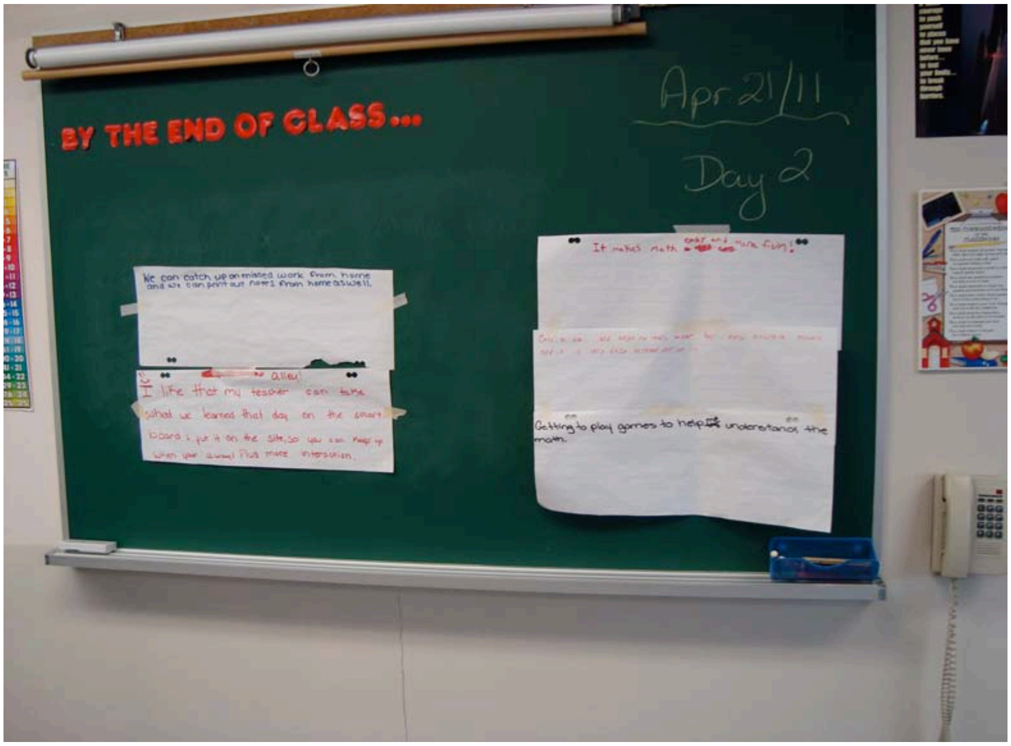
In the second phase of the session students were asked to read one another's responses, which had been posted on the front wall of the classroom. Students then had three opportunities to move their chart paper idea to an idea that they felt was similar. Digital photos were taken as part of the documentation of this process. The photos included show individual student responses posted in random locations at the beginning of the second phase of the session as well as one of their first attempts at grouping ideas together.



An individual student's response to the initial prompt posted for all to read.



An individual student's response to the initial prompt posted for all to read.



Students moving their individual responses to begin to form groups of related ideas.

Through moving their ideas around, the students eventually formed five self-selected groups of ideas that became the basis for forming discussion groups of 2-6 students. The chart paper notes that were taken in these discussion groups are shown in the table below.

Group A	Smart Boards are a great way to learn in math class due to the fact that we are able to interact with our learning. To most it's a better method to comprehend our learning then it would be to write on the chalk or white board. We are able to go up & physically go up & move the objects. For an ie. Geo, with shapes, formula (shapes), pics for Pythag [Pythagorean theorem] for visual learners.
Group B	Interacting. Organized it makes an organized Brain!! If we are Absent, the teacher can post that day's lesson on the website exactly how the class learned it. Make fun time in classroom! Our notebook pages can be put on the board and we can copy the notes into our books. Teacher can show the calculator on the board.
Group C	It helps us understand the math a lot more better and makes it much more easier. It also helps teachers save class work from another day then having to write it over again.

	Playing games like Kosh [sic] ball were you throgh [sic] a ball at the smart board at targets (circles) and a question pops up and the class has to answer it. This game helps us study what we are learning in the lesson that your in.
Group D	Smart board: - it's helpful - fun to use - hands on - gets us more involved - koosh ball - vortex - we can move things around - enviromentaly [sic] friendly (no paper) - can see what the teacher wrote on it during class, via the website, if you missed a day - a HUGE comper [computer] on the wall - touch screen - we like drawing on the board - playing the games is fun
Group E	On a smartboard you can transfer the lesson online from the smartboard directly, with the exact teachers wrighting [sic]. It helps People with disabiltys [sic] who cannot wright out notes to get the exact notes the teacher wrote. Plus it IS WAY HARDER to catch up on a chalkboard. SMART board = [happy face]

Characteristics of IWB Use

In their statements during the open space session, the students' highlighted a number of ways that the IWB is used during mathematics lessons that they perceived as important. These patterns of use fall into two major categories: 14 of the statements made direct reference to the use of the IWB to display instructions and notes, while 22 statements refer to manipulating mathematical representations or playing games using the IWB technology.

Referring to ways the IWB was used to display instructions and notes, students highlighted practices such as displaying notes from previous lessons when needed. As one group of students noted, "It also helps teachers save class work from another day then having to write it over again". As this comment typifies, many of the statements made about patterns of use that involved instructions and notes focused on the time and effort that could be saved by using the IWB. Other comments, however, speak to greater advantages of giving instructions and notes on the technology. For example, one student stated, "We can catch up on missed work from home and we can print out notes from home as well". This student refers to the way that instructions and notes displayed on the IWB can be shared on a website that students can access from home. To display notes on an IWB, teachers must create them in a digital form.

Once in a digital form, instructions and notes can be stored, shared and retrieved in a wide variety of ways including on a website for students to access.

The other major pattern of use that students highlighted in their statements during the open space session is the manipulation of mathematical representations. The comments made indicate that the students often used the IWB in activities that they perceived to be gaming. In one example, a group of students described how they enjoyed, "Playing games like Kosh [sic] ball were you throgh [sic] a ball at the smart board at targets (circles) and a question pops up and the class has to answer it. This game helps us study what we are learning in the lesson that your [sic] in". In the activity the students describe, they throw a soft rubber 'Koosh' ball at targets on the IWB to reveal and select mathematics problems and answers. While this use of the interactive affordances of the technology is not directly related to performing mathematics, the students' comments indicate that these kinds of game features make activities more enjoyable and engaging. Other students, however, did refer to ways that the interactive features of the IWB were used for directly manipulating mathematical concepts, stating for instance, "We are able to go up & physically go up & move the objects. For an ie. Geo [Geometers' Sketchpad], with shapes, formula (shapes), pics for Pythag [Pythagorean theorem] for visual learners". Such comments indicate that beyond the use of the interactive features of the IWB for adding gaming elements to mathematical activities, the students also value the use of interactive features for working with mathematical concepts themselves.

Perceived Effects of IWB on Student Learning

While only a few more than half the students choose the option "I feel the SMART Board has helped my math learning" during the clicker survey, several students made statements during the open space session that describe ways they feel IWB use has supported their learning. Several students wrote individual statements that explicitly refer to ways they believe the IWB makes learning mathematics easier. For example, one student wrote, "There is a lot more that can be done on a smartboard than a chalkboard and it's very organized which makes it easier to learn". Similarly, several individual students and groups made statements that refer to how the IWB helps in making lessons more organized. One group described the technology as, "Organized it makes an organized Brain!!". This sentiment characterizes statements written by several students and expressed during the discussion periods of the open space session.

Another theme in students' perceptions of ways that IWB use supports mathematical learning relates to ways the technology helps students with learning disabilities. During the open space session, one group of students in particular wrote that their teacher's ability to present and record notes and instructions with the IWB was helpful for all but especially for students who struggle with understanding written notes and taking notes themselves. They wrote, "On a smartboard you can transfer the lesson online from the smartboard directly, with the exact teachers wrighting [sic]. It helps People with disabiltys [sic] who cannot wright out notes to get the exact notes the teacher wrote. Plus it IS WAY HARDER to catch up on a chalkboard.

SMART board = [happy face]”. Later in the discussion, one student in this group shared that she has been identified with a learning disability and noted how helpful she found the note taking and presentation features of the IWB for her learning.

Discussion of Key Observations

In this section we discuss nine key observations that emerged from the various data sources in this study. Each key observation is briefly described, connections are made to the literature reviewed and, where appropriate, recommendations for practice and/or future research are made.

I. Teacher Practices & Usage

Teachers use of IWB technology begins with an emphasis on use as a display and gradually transitions into use of the more dynamic and interactive affordances of this technology.

The results from the teacher questionnaire suggest that while intermediate mathematics teachers in these two school boards make frequent use of the IWBs in their classrooms, they tend to make more limited use of the dynamic and interactive features of mathematics specific software available for IWBs. When asked to describe how their students typically use the IWB in their classrooms, less than one third of participants described students using interactive features of the technology. In contrast, the teachers who participated in the classroom observation and follow-up interviews were using a variety of mathematics specific software including Geometer’s Sketchpad, TI Emulator, SMART Board Math Tools, the National Library of Virtual Manipulatives, TIPS Grade 9 Applied lessons for IWB, and materials from the Nelson website developed for use on IWBs.

This contrast in practices is not surprising given that teachers who have experienced success with the use of a technology are more likely to volunteer to participate in classroom observation sessions about that technology. Moreover, the classroom observations and teacher interviews provides us with some insights as to how teachers with adequate time and support can move from using the static features of the IWB to more fully engaging the interactive affordances of this technology. In particular, Fiona describes a key factor that led to her use of the IWB as an interactive tool was the acquisition of SMART Board Math Tools and being introduced to the National Library of Virtual Manipulatives. As she states, “It [the IWB] can be more than a projector and more than a blackboard if you have the interactive tools to go with it, otherwise it’s just a whiteboard”. Fiona also explained that the other teachers in her school did not have the SMART Board Math Tools resource during their first year using the IWB but, having seen what Fiona is able to do, these teachers have requested this resource for next year. Clearly, if Fiona’s colleagues were answering the teacher questionnaire they would be less likely to indicate interactive uses of the IWB as they did not have access to as many math specific interactive tools as Fiona did.

As suggested in the research, teachers may begin to use this complex technology primarily as a projection and display device but gradually through the addition of peripheral devices, increased familiarity with software, interactive websites and the various affordances of the IWB, they begin to use this technology more fully (Smith, Higgins, Wall & Miller, 2005). Indeed, we saw evidence that at least five of the ten key affordances identified by Mercer, Hennessy and Warwick (2010) were in use in the classrooms we observed. Specifically, these teachers were using the drag and drop, hide and reveal, indefinite storage and quick retrieval, feedback, and annotation affordances of the IWB in their mathematics programs. Mercer, Hennessy and Warwick suggest that the use of the IWB in this manner fosters rich dialogic spaces that can enhance students' learning.

While the data sources in this study provided valuable information about teacher practices and usage of IWB technology, more extended case studies including classroom observations over several days or weeks as well as interviews with students would provide more detailed information about the ways that teachers make the transition from the use of the IWB as a static display to more interactive uses. It might also be interesting to repeat the teacher questionnaire in a year's time when these teachers have had a chance to acquire more of the mathematics specific interactive software for the IWB.

IWBs are a complex technology that can take approximately two years to incorporate into teachers' classroom practice.

As noted in the literature review, a long-term study of IWB use in British primary schools suggests that only after two years with the technology in classrooms do significant changes in pedagogical practice develop (Somekh et al., 2007). The findings of our study are in keeping with the observations of Somekh et al. Rachel, the Grade 9 teacher we observed, indicated that it had taken her about 18 months to incorporate the IWB technology into her Grade 9 Applied mathematics program. During this time she increased her competence in resolving technical issues, became familiar with a variety of resources and related technologies for use with the IWB, and then successfully incorporated the technology into her pedagogical approach. She explains "When I first got the SMART Board I was so concerned with the functionality of the technology that I actually lost a little bit of the math for a while." Only once she became more skilled in using the IWB and related technologies was she able to focus on specific ways to enrich her mathematics program.

Our observations and conversations with the Fiona, the Grade 7 teacher, provide additional insight into this process. Fiona was in the midst of her first year using the IWB in her classroom. In our observations we noted that she was still spending significant amounts of time resolving technical issues as well as developing classroom management techniques to more successfully integrate the IWB and netbook technologies into her pedagogy. Fiona indicated that she had learned a great deal about using these technologies but needed more time to continue to explore their use. Visiting her classroom a year from now would certainly enrich our understanding of the process of incorporating this technology into classroom practice.

With regard to use of the iPod Touch, Charles was in his first year of using this technology in his classroom. He had gradually expanded his use from geography to Grade 12 law and a Grade 10 parenting course. Charles' experience suggests that the technical aspects of the iPod Touch are considerably less challenging than the IWB but time is still needed to find suitable apps and websites and to develop effective classroom management routines with regard to distributing, collecting and charging the devices and to ensuring that students' digital privacy is maintained.

Thus, on the basis of this pilot study as well as published research, both teachers and administrators should expect that it will take at least two years with adequate support for these technologies to be effectively integrated into classroom practice. Explicit statements to this effect might be helpful in reducing teachers' feelings of frustration or their sense of being overwhelmed by the steep learning curve associated with this technology.

Teachers are creating and managing a complex and dynamic digital landscape or technological ecosystem within their classrooms.

The IWB can be a powerful technology but it does relatively little to enhance classroom practice when used on its own. It is only when connected to or integrated with other devices that the IWB has the potential to dramatically change classroom practice (Higgins, Beauchamp & Miller, 2007). Our classroom observations and teacher interviews provide several examples of the integration of various digital technologies. Rachel has integrated the IWB, a laptop, a projector, a document camera, student owned TI-Nspire devices, and a variety of software applications with the class website she created. Fiona has integrated the IWB and netbooks in her classroom with online resources such as the National Library of Virtual Manipulatives. While Charles has found a number of apps and web resources for use with the iPod Touch devices, he finds the lack of integration between the iPod Touch device and the IWB in his classroom to be a serious limitation in using the iPod Touch effectively. In addition, in their responses to the constructed-response items on the questionnaire, several teachers mentioned the integration of the IWB with other technologies in their classrooms. These observations highlight the way that teachers are essentially creating and managing a digital landscape or technological ecosystem using the available resources in their classroom.

We also see evidence that the digital landscape that is created is quite dynamic. In our interview with Rachel she noted that she was looking forward to the introduction of the TI-Navigator system in her classroom that would take place next year so that she could project individual students' graphing calculators onto the IWB. She also noted that she would be getting a SMART Board document camera that would more effectively integrate with the IWB than the document camera that she was using at the time of our visit. As Rachel's digital landscape changes, her pedagogical approaches will also change. Similarly, Fiona was hoping that she could connect students' netbooks to the IWB to facilitate sharing and collaboration. This change in the digital landscape would result in a series of changes in her pedagogy.

Through our observations and interviews, we see the need for infrastructures that facilitate the sharing of experiences with different technological ecosystems. As teachers like Fiona and Charles integrate new technologies into their practices and try new combinations, it is important that their learning is shared with colleagues so that teachers seeking new approaches can benefit from their challenges and successes. This suggests the need for ongoing support that emphasizes and provides venues for teachers to share their experiences with technologies, and for continued research that collects and synthesizes the pitfalls and advantages of different configurations and practices.

II. Ways the Technologies Support Student Learning

Both students and teachers believe that IWBs and iPod Touch devices increase the level of engagement of students.

A consistent observation across all the data sources in this study is the perception that IWBs and iPod Touch devices increase students' level of engagement in the classroom. This finding is consistent with the findings of Crichton et al. (2011) who found that the use of iPod Touch devices resulted in increased levels of student engagement particularly for intermediate level students who were less successful in school (see Review of Recent Literature).

Several teachers responding to the constructed-response items on the questionnaire expressed the view that the IWB increases students' level of engagement. In addition, both teachers who participated in the classroom observation part of the study commented on the way the IWB engages students. As expressed by Rachel, "It's just so much better at making sure that they are with me". Similarly, Charles noted that many of the students in his essentials level course had not had previous opportunities to work with iPod Touch devices and were very enthusiastic about learning to use the technology.

The responses and comments of students in the Open Space Technology session also reflect this view. Many students described the increased level of interaction in their math lessons that results from using the IWB. They indicated that using the IWB meant they were more involved in their math lessons and that they were learning mathematics while playing games and having fun. As one student wrote, "It's interactive and a great and fun way to learn math easily without misunderstanding the lesson".

Further research would be useful in revealing which specific aspects of these technologies contribute to increased levels of engagement as well as the extent to which some students may find the technology distracting.

Both students and teachers believe that the specific affordances of the IWB and its peripherals enrich their mathematics learning.

In addition to increasing their level of engagement, the students and teachers who participated in this study believe that the specific affordances of the IWB and its peripheral devices support and enrich their learning. As described in the Observations section, this finding was evident in all the data sources in this study. More specifically, both students and teachers indicated that visual representations of mathematical concepts and the ability to move objects around on the IWB enhanced their understanding of mathematics concepts.

And yet, while 58% of students who participated in the open space session felt that the IWB helped their learning, 85% indicated that this technology should be installed in all classrooms. The disparity between students' opinions on whether or not IWB use had helped their learning and whether or not they should be installed in all classrooms suggests that while the students appreciate the technology and value its features, they do not necessarily consider its use to relate to their learning. This may speak to the ways the technology is used and indicate that, from the students' perspective, it is not always used in ways that support their learning. This observation may also relate to the length of time that teachers have had to incorporate this technology into their classroom practice.

While this pilot study clearly indicates that students and teachers believe the IWB enhances their mathematics learning, more research is needed to provide evidence that this technology does have a positive impact on learning and to better understand the nature of that impact. This finding is similar to the findings of researchers such as Beeland who as early as 2002 suggested that the enthusiasm in the educational community for the introduction of IWBs in classrooms necessitated research into their influence on learning. Despite such calls for research, to date investigations of the pedagogical effectiveness of IWBs have been relatively few and far between (Mercer, Hennessy, Warwick, 2010).

Some students and teachers have the perception that IWB and iPod Touch technologies are particularly beneficial for students who are struggling academically.

An interesting finding from several data sources in this pilot study is that a number of participating teachers and some students have the perception that IWB and/or the iPod Touch technologies are particularly beneficial for students who are struggling academically. As noted in the Observations section, this perception may involve both the sense that increasing levels of engagement is particularly important for these students as well as the sense that the particular affordances of these technologies are especially beneficial for students who are struggling with the learning process. Similar to the findings of researchers investigating other subject areas such as science (Hennessy, Deaney, Ruthven, & Winterbottom, 2007), several teachers in this study felt that the visual representation of mathematical ideas was particularly helpful for struggling students and others indicated that being able to get up from their seats and interact with objects on the IWB was also particularly beneficial for struggling students.

This is clearly an area where additional research is urgently needed. More specifically, gathering additional information about the reasons for this perception as well as evidence of the effectiveness of these technologies for struggling students would be very beneficial.

III. Supports for Implementing these Technologies

Teachers require time and ongoing support to successfully integrate these technologies into their classroom practice.

From the various data sources in this study, the following five forms of support for integrating these technologies into classroom practice have emerged as particularly effective:

- *(1) Working with Colleagues* Working with colleagues was identified as a key form of support both in the questionnaire responses, by the Grade 9 teacher we observed and in the iPod teacher interview. This form of support was less evident for the Grade 7 teacher we observed likely due to the fact that the Grade 7 and 8 program in her school had just been established and teachers had had little time to get acquainted with one another. The importance of working with colleagues observed in this pilot study is consistent with many other studies on effective forms of teacher professional development and underscores the need to provide time for teachers to collaborate when introducing new technologies into a school.

- *(2) Board Consultants and/or PD Workshops* The questionnaire responses and comments of the classroom observation teachers indicate that board consultants and board initiated PD workshops are another key form of support. To provide maximum benefit, one of the participating teachers noted that PD support should be offered a little at a time so that teachers do not feel overwhelmed by the technology and have time to try out new features in their classrooms.

- *(3) Time* The need for time to implement new technologies is well documented in existing research and was repeatedly emphasized by the questionnaire participants and both classroom observation teachers who participated in this study.

- *(4) Students* Both classroom observation teachers indicated that students were a key form of support helping them to integrate this technology into classroom practice. Students were able to troubleshoot a variety of technical issues and were also able to alert teachers to various specific features of the IWB based on experiences they had had in previous classrooms. This is an interesting observation and highlights the notion that introducing technologies such as the IWB and iPod into classrooms may contribute to the creation of effective classroom communities where students and teachers collaborate in the co-construction of knowledge. While some published research on the role of students in supporting the use of new technologies may be available, we feel that this is another area where additional study would be beneficial.

- *(5) Access to Developed Curriculum-related Resources* Several data sources in this study highlight the importance of teachers having access to fully developed curriculum specific resources for use with these technologies. With regard to the use of the iPod Touch, Charles identified the need for more grade and curriculum specific apps. This observation is consistent with the findings of Crichton et al. (2011). Further, both classroom observation teachers emphasized the tremendous value of using previously developed grade and curriculum appropriate resources such TIPS lessons for Grade 9 Applied mathematics, the National Library of Virtual Manipulatives, and the IWB lessons included on the Nelson textbook website. One recommendation which emerges from this observation is that school boards may want to create an online repository or catalogue of resources by subject, grade & strand for IWB and iPod applications which teachers could both contribute to and make use of as they continue to incorporate these technologies into their classrooms.

Support that addresses both technological and pedagogical aspects of using IWB and iPod Touch devices in the classroom is more beneficial than providing technological support alone.

The findings of the questionnaire with regard to usage habits indicate that many teachers tend to make limited use of the dynamic and interactive features of the combination of IWBs with mathematics specific software and that the focus of existing support is on negotiating technical issues. These findings suggest the need for somewhat different types of professional development. More specifically, professional development supporting teachers' technical competences while exposing them to new pedagogical approaches for using the technology in combination with different software may be the most beneficial. The findings of this study suggest that it is important that all support, whether it be focused on fostering the basic technical competences needed to use a technology or on more advanced usage, be situated within a frame that maintains the centrality of the pedagogical goals for a technology's use.

IV. An Additional Benefit

IWB technology promotes and facilitates the recording and storage of lessons, which is beneficial in several ways.

In our investigation, we found that IWB use facilitated and promoted teachers' recording of both their own activities and the activities of their students. We noted this to be beneficial in several ways. In particular, it helps teachers in their lesson planning approach by supporting the addition of annotations and explanations within files used during lessons. In our observations we noted that much like teachers tend to make additions to notes on a blackboard as a lesson progresses, the teachers added to the files they had prepared for display to students by writing directly on them with the IWB pen tool. Unlike a blackboard, however, the IWB allowed the teachers to save their annotations. With their annotations and modifications saved, the next time the lesson is taught the teacher can make adjustments based on the information included in the files. Such enhanced record keeping can also be beneficial for professional development activities and/or as teachers share with each other. Equally, another benefit of this affordance is that external researchers and classroom teachers engaged in action research can access detailed screen captures from a series of lessons and these become a rich data source.

References

Allan, J., Smyth, G., l'Anson, J. & Mott, J. (2009). Understanding disability with children's social capital. *Journal of Research in Special Needs Education* 9(2), 115-121.

Banister, S. (2010). Integrating the iPod Touch in K-12 education: Visions and vices. *Computers in the Schools*, *27*(2), 121-131. doi:10.1080/07380561003801590

Beeland, W. D. (2002). *Student engagement, visual learning and technology: Can interactive whiteboards help?* Proceedings from Annual Conference of the Association of Information Technology for Teaching Education, Dublin.

Brooks, C., & Adams, C. (2011) Personalizing learning: iPod touch devices in K-12 classrooms. Paper presented at the annual meeting of the Canadian Society for the Study of Education, Fredericton, NB.

Crichton, S., Pegler, K., White, D., Onguko B. (2011). Interactive whiteboards: Same sage on a 21st century stage? Paper presented at the annual meeting of the Canadian Society for the Study of Education, Fredericton, NB.

Drijvers, P., & Trouche, L. (2008). From artifacts to instruments: A theoretical framework behind the orchestra metaphor. In K. Heid & G. Blume (Eds.), *Research on technology and the teaching and learning of mathematics: Vol. 2. Cases and perspectives* (pp. 363-391). Charlotte, NC: Information Age Publishing.

Drijvers, P., & Weigand, H.-G. (2010). The role of handheld technology in the mathematics classroom. *ZDM Mathematics Education,* DOI: 10.1007/s11858-010-0285-2. doi:10.1007/s11858-010-0285-2

Edwards, J.-A., Hartnell, M., & Martin, R. (2002). Interactive whiteboards: Some lessons from the classroom. *Micromaths*, *18*, 30-33.

Glover, D., & Miller, D. (2001). Running with technology: The pedagogic impact of the large-scale introduction of interactive whiteboards in one secondary school. *Technology, Pedagogy & Education*, *10*(3), 257-278. doi:10.1080/14759390100200115

Hammond, D. L., Whatley, A. D., Ayres, K. M., & Gast, D. L. (2010). Effectiveness of video modeling to teach iPod use to students with moderate intellectual disabilities. *Education and Training in Autism and Developmental Disabilities*, *45*(4), 525-538.

Harlow, A., Cowie, B., & Heazlewood, M. (2010). Keeping in touch with learning: The use of an interactive whiteboard in the junior school. *Technology, Pedagogy & Education*, *19*(2), 237-243. doi:10.1080/1475939X.2010.491234.

Hennessy, S., Deaney, R., Ruthven, K., & Winterbottom, M. (2007). Pedagogical strategies for using the interactive whiteboard to foster learner participation in school science. *Learning, Media & Technology*, *32*(3), 283-301. doi:10.1080/17439880701511131

Higgins, S., Beauchamp, G., & Miller, D. (2007). Reviewing the literature on interactive whiteboards. *Learning, Media & Tech.*, *32*(3), 213-225. doi:10.1080/17439880701511040

Jewitt, C., Moss, G., & Cardini, A. (2007). Pace, interactivity and multimodality in teachers' design of texts for interactive whiteboards in the secondary school classroom. *Learning, Media and Technology*, *32*(3), 303-317. doi:10.1080/17439880701511149

Kelly, A. M. (2011). Teaching Newton's laws with the iPod touch in conceptual physics. *The Physics Teacher*, *49*(4), 202.

Kershner, R., Mercer, N., Warwick, P., & Kleine Staarman, J. (2010). Can the interactive whiteboard support young children's collaborative communication and thinking in classroom science activities? *Computer Supported Collaborative Learning*, *5*(4), 359-383. doi:10.1007/s11412-010-9096-2

Latham, P. (2002). *Teaching and learning mathematics: The impact of interactive whiteboards - Results of the North Islington Education Action Zone RM Easiteach Mathematics Project.* London: BEAM Education.

Mercer, N., Hennessy, S., & Warwick, P. (2010). Using interactive whiteboards to orchestrate classroom dialogue. *Technology, Pedagogy and Education*, *19*(2), 195-209. doi:10.1080/1475939X.2010.491230

Monk, N. (2011). The CAPITAL Centre Creativity and Performance in Teaching and Learning Open-Space Learning http://www2.warwick.ac.uk/fac/cross_fac/capital/ University of Warwick. Accessed May 24, 2011.

Owen, H. (2008). Open Space Technology: A User's Guide. San Francisco, CA: Berrett-Koehler Publishers.

Perkins, S., & Saltsman, G. (2010). Mobile learning at Abilene Christian University: Successes, challenges, and results from year one. *Journal of the Research Center for Educational Technology*, *6*(1), 47-54.

Roschelle, J., Kaput, J., & Stroup, W. (2000). SimCalc: Accelerating student engagement with the mathematics of change. In M. Jacobsen & R. Kozma (Eds.), *Learning the sciences of the 21st century: Research, design, and implementing advanced technology learning environments* (pp. 47-75). Hillsdale, NJ: Erlbaum.

Smith, H. J., Higgins, S., Wall, K., & Miller, J. (2005). Interactive whiteboards: boon or bandwagon? A critical review of the literature. *Journal of Computer Assisted Learning*, *21*(2), 91-101.

Somekh, B., Haldane, M., Jones, K., Lewin, C., Steadman, S., Scrimshaw, P., … Woodrow, D. (2007). *Evaluation of the Primary Schools Whiteboard Expansion Project: Report to the Department for Children, Schools and Families.* London: Becta.

Sprague, D., & Pixley, C. (2008). Podcasts in education: Let their voices be heard. *Computers in the Schools*, *25*(3), 226-234. doi:10.1080/07380560802368132

Suurtamm, C., & Graves, B. (2007). *Curriculum Implementation Intermediate Math (CIIM) [Research Report, Year 1]*. Ottawa, Ontario, Canada: Faculty of Education, University of Ottawa.

Tatar, D., Lin, S., & Dickey, M. (2005). Visualizing handheld-based classroom activity. In *Proceedings of the 2005 International Symposium on Collaborative Technologies and Systems* (pp. 313-320). St. Louis: IEEE.

Trouche, L., & Drijvers, P. (2010). Handheld technology for mathematics education: flashback into the future. *ZDM,* doi:10.1007/s11858-010-0269-2. doi:10.1007/s11858-010-0269-2

Vess, D. L. (2006). History to go: Why iTeach with iPods. *The History Teacher*, *39*(4), 479-492.

Wang, Y. (2009). Open space learning circle and active learning in English communication class. European Journal of Social Sciences 11(3), 477-485.

APPENDIX A

TEACHER QUESTIONNAIRE ON INTERACTIVE WHITEBOARD USE IN MATHEMATICS CLASSES

0%

Using New Technologies in Intermediate Classrooms

Interactive Whiteboard Use in Mathematics Classes

This research, funded by Ottawa Region MISA/PNC, considers how the introduction of interactive whiteboards (SMART Boards) supports student learning in intermediate mathematics classrooms. In this survey we'll be asking you a series of questions about how you use interactive whiteboards and your sense of how this technology supports student learning.

The survey should take about 20 minutes to complete. Please complete this survey in one session so that your responses will be saved.

Before participating in this survey you should be aware of the following:

- Your responses will be kept confidential and your participation is anonymous.
- When research results are reported, any characteristics that might identify you, your students or your school will be removed to protect your anonymity.
- There are no anticipated risks associated with participating in this study.
- Your participation in this study is completely voluntary, and you may withdraw at any time without penalty.
- You may withdraw by closing your browser at any time.

Which school board do you teach in?

- ○ Ottawa Catholic School Board
- ○ Renfrew County District School Board

The focus of this survey is the use of interactive whiteboards in Grade 8 and 9 mathematics courses. Which mathematics course(s) do you teach?

Check all that apply

- ☐ Grade 7 and/or 8
- ☐ Grade 9 Applied
- ☐ Grade 9 Academic

How often do you use an interactive whiteboard?

- ○ Every class
- ○ Most classes
- ○ Occasionally
- ○ Never
- ○ Other, please specify: ______

Which software do you use with the interactive whiteboard?

Check all that apply

- ☐ Presentation software (e.g. Powerpoint)
- ☐ Video (online or on computer)
- ☐ Web browser (e.g. Firefox)
- ☐ Spreadsheet or statistical software (e.g. Excel, Fathom)
- ☐ Word processor (e.g. Word)
- ☐ Graphing calculator emulator (e.g. TI-Nspire Teacher Edition)
- ☐ Graphing software (e.g. Tinkerplots)
- ☐ SMART Notebook
- ☐ Other, please specify: ______

Please describe how YOU typically use the interactive whiteboard during mathematics classes.

How often do students in your mathematics class(es) share their work using the interactive whiteboard?

- Every class
- Most classes
- Occasionally
- Never
- Other, please specify:

Please describe how STUDENTS in your classroom typically use the interactive whiteboard.

How would you characterize the effect of interactive whiteboard use on student learning in your mathematics class(es)?

- Entirely positive
- Mostly positive
- Somewhat positive
- Neither positive nor negative
- Somewhat negative
- Mostly negative
- Entirely negative

In which curriculum strands do you find using the interactive whiteboard to be particularly effective for supporting students' understanding of mathematical concepts?

Check all that apply

Grade 7/8

- Number Sense & Numeration
- Measurement
- Geometry & Spatial Sense
- Patterning & Algebra
- Data Management & Probability

Grade 9 Academic

- Number Sense & Algebra
- Linear Relations
- Measurement & Geometry

- [ ] Analytic Geometry

Grade 9 Applied

- [ ] Number Sense & Algebra
- [ ] Linear Relations
- [ ] Measurement & Geometry

Please describe one experience where you felt that the interactive whiteboard was particularly effective in supporting student learning in mathematics.

Do you find the interactive whiteboard helpful for differentiating instruction and/or as an assistive technology in your classroom?

Please explain your answer

Describe any challenge(s) that you feel have reduced the usefulness of the interactive whiteboard in supporting student learning. How could those challenge(s) be reduced?

How would you characterize the level of support you have received for integrating interactive whiteboards into your practice?

- ( ) Excellent
- ( ) Good
- ( ) Adequate
- ( ) Poor

What kinds of support have you received for using the interactive whiteboard?

Check all that apply

- [ ] Board initiated professional development
- [ ] School initiated professional development

- [ ] Collaboration with colleagues
- [ ] Technical support from school board
- [ ] Technical support within your school
- [ ] Technical support from manufacturer
- [ ] Online forums/groups
- [ ] None
- [ ] Other, please specify:

Describe an instance when you have had a problem or question about using interactive whiteboards. How did you solve/answer it?

Describe an instance when you shared a way of using interactive whiteboards with colleagues.

Submit

Survey Software powered by FluidSurveys

APPENDIX B

OTTAWA REGION MISA/PNC TEACHER QUESTIONNAIRE DATA

Ottawa Region MISA/PNC – Teacher Survey Results (Selected Response Items)

Which school board do you teach in?

Ottawa Catholic School Board	47%	7
Renfrew County District School Board	53%	8
	Total:	15

The focus of this survey is the use of interactive whiteboards in Grade 7, 8 and 9 mathematics courses. Which mathematics course(s) do you teach?

Grade 7 and/or 8	50%	7
Grade 9 Applied	43%	6
Grade 9 Academic	21%	3
	Respondents:	14

How often do you use an interactive whiteboard?

Every class	60%	9
Most classes	27%	4
Occasionally	7%	1
Never	0%	0
Other, please specify	7%	1
	Total:	15

Other:

- About 80% of classes

Which software do you use with the interactive whiteboard?

Presentation software (e.g. Powerpoint)	73%	11
Video (online or on computer)	80%	15
Web browser (e.g. Firefox)	73%	11
Spreadsheet or statistical software (e.g. Excel, Fathom)	27%	4
Word processor (e.g. Word)	87%	13
Graphing calculator emulator (e.g. TI-Nspire Teacher Edition)	33%	5
Graphing software (e.g. Tinkerplots)	20%	3
SMART Notebook	100%	15
Other, please specify	13%	2
	Respondents:	15

Other:

- Geometer's Sketchpad
- Gizmos smart exchange

How would you characterize the effect of interactive whiteboard use on student learning in your mathematics class(es)?

Entirely positive	53%	8
Mostly positive	40%	6
Somewhat positive	7%	1
Neither positive nor negative	0%	0
Somewhat negative	0%	0
Mostly negative	0%	0
Entirely negative	0%	0
	Total:	15

In which curriculum strands do you find using the interactive whiteboard to be particularly effective for supporting students' understanding of mathematical concepts?

Grade 7/8

Number Sense & Numeration	62%	5
Measurement	100%	8
Geometry & Spatial Sense	75%	6
Patterning & Algebra	88%	7
Data Management & Probability	88%	7
	Respondents:	8

Grade 9 Academic

Number Sense & Algebra	100%	4
Linear Relations	100%	4
Measurement & Geometry	100%	4
Analytic Geometry	100%	4
	Respondents:	4

Grade 9 Applied

Number Sense & Algebra	80%	4
Linear Relations	80%	4
Measurement & Geometry	80%	4
	Respondents:	5

How would you characterize the level of support you have received for integrating interactive whiteboards into your practice?

Excellent	33%	5
Good	40%	6
Adequate	7%	1
Poor	20%	3
	Total:	15

What kinds of support have you received for using the interactive whiteboard?

Board initiated professional development	67%	10
School initiated professional development	27%	4
Collaboration with colleagues	87%	13
Technical support from school board	53%	8
Technical support within your school	13%	2
Technical support from manufacturer	13%	2
Online forums/groups	0%	0
None	0%	0
Other, please specify	33%	5
	Respondents:	15

Other:

- We learn together, as we go!
- Took computers in ed part one very helpful
- Self taught
- Snip-its with other teachers has been by far the most valuable.
- Other board/school support has been offered, but I have not used it to this point

Please describe how YOU typically use the interactive whiteboard during mathematics classes.

1	I have prepared lessons that I work with the students during the lesson but have them come up to the board as much as possible because it is a learning tool for them. Getting them involved in the lesson gets them more at ease in the classroom and they find math fun.
2	-lessons are prepared for and delivered -interactive activities that bring students to the board -showing videos and powerpoints embedded in lessons -to save notes for website posting
3	It has replaced the blackboard. Use it everyday. Often have calculator emulator up. Often have interactive slides. Use if for demos and note taking. Have a review game with students throwing stuff at the board for a game.
4	The students homework assignments and daily lessons are saved for further reference. Use the math tools depending on the strand (ie. graphs for Data Management). We use the smart notebook lessons too.
5	I demonstrate work on the Smartboard, using it much like a traditional chalk board. I also use interactive technologies such as online protractors, rulers, spinners, dice, timers etc. I also use the Smartboard to view slide shows, present assignments/tasks, math tutorials. We use it for electronic manipulatives. So many ways! We also use the Smartboard for research to clarify math concepts.
6	Student question and answer as well as online interactive math games as a reinforcement.
7	I offer questions for the students to solve. They also present work they have completed on problem solving. We use math smart tools to help work through problems/questions.
8	notes examples of work graphing visual aids
9	I use it to take up work - use grids to show graphing....I also do a group note at the beginning to start the lesson... I would use it mostly as a chalkboard I think....
10	Daily notes are placed on the smartboard and are used for reference. Problem solving solutions are recorded on the smartboard typically by students. Student work, both simple and complex is photographed using the document camera and placed on the smart board. Approaches are examined and manipulated by the class, and referenced in future classes.
11	I use the interactive whiteboard to introduce a lesson/concept. For example, using the different types of measurement tools in Smart Notebook, I can demonstrate different units and measurements to determine area/perimeter of 2D shapes. The students benefit as they have the opportunity to engage with the material as a group.
12	Lessons have already been made up for this course in Notebook based on TIPS. I go through the lesson with the students using the SMART board
13	I started using it this semester for the first time.

Please describe how STUDENTS in your classroom typically use the interactive whiteboard.

1	Students share their homework answers on the whiteboard. They also share their thinking during the lesson. I show the students different methods of solving the problem and allow them to choose which method works for them.
2	-will write solutions to questions -prepared activities that they move things around (flash apps)
3	Put answers on board and solve solutions.
4	Most classes students come to the smartboard to show how they completed a question. Students show different ways of completing the same question, side by side. We have watched math videos describing differentiated teaching of mathematics also.
5	They use the whiteboard to show solutions to problems, demonstrate their understanding, interact with software such as using Geometer's sketchpad, use spinners, timers, etc. Students use the protractors, ruler etc. to measure angles, side lengths. Students use the Smartboard to show their thinking and share their ideas.
6	To demonstrate or model specific questions related to content we are covering. For example today students modeled division questions from their homework.
7	In Math they work in partners to solve problems/questions using the math tools.
8	students write solutions and use some of the manipulatives i.e. dice, spinners etc. we have also graphed together using the whiteboard and their netbooks
9	They will come up and show their answers or answer a class question. They show their method. They can also play the occasional game to show their understanding... We use one game with balls with positive and negative numbers they must touch in order for example.
10	They show solutions, record ideas, and manipulate concepts.
11	Students use the whiteboard to practice after a lesson/particular concept has been introduced to them. Students who are having more difficult with seatwork can use the whiteboard to help with the understanding before beginning a math task.
12	Students come up to write their solution to a homework question or an example.

Please describe one experience where you felt that the interactive whiteboard was particularly effective in supporting student learning in mathematics.

1	My ELL students find it easier to show their understanding on the board instead of sharing it aloud with their peers. I had one student willing to be taped on Notebook and he usually didn't want to volunteer answers in class.
2	-can't think of ONE - something new/different happens every day!
3	Really helps with graphing because I can put the graph up and then write on it and show them what they mean and it is really visual for them.
4	One class we were learning about integers and the students were having difficulty with the concepts. By using specific colours (ie. red/negative and black/positive) the students had a visual representation of the integer process. Another time we watched a video on the student brain and math thought process, and many of the students could see themselves in the video. "Ya, I learn that way also."
5	When one student shares their own solution to problems, we can shrink it - and have multiple students come up and demonstrate their math strategies. It is very powerful for students to see each other's work and see new and multiple ways of solving problems. They are very comfortable interacting with the Smartboard - using a wide variety of features, such as the grid paper background and other tools.
6	using gizmos to show distance time graphs using the presentation software to show perimeter using presentation software to show Pythagorean work
7	I found it most effective in data management where graphs can be displayed and manipulated right away by the teacher or student.
8	Using the math tools assisted with hands on learning and it engaged all students to encourage and assist each other with the math process and problem solving.
9	translations rotations reflections for transformational geometry using geometer sketchpad. It was easy for the students to see the movements on the Cartesian plane
10	Using a grid allows the graphing to be so much more accurate....I can show them a reflection or a rotation about the x or y axis so much easier.
11	Using and manipulating algebra tiles to balance scales using both the document camera and the ink layer.
12	One experience where students found the interactive whiteboard highly effective in math was during a Data Management lesson where students required to graph their information using a scatter plot graph. They could easily see and form the trends and discuss different variables and biases based on their information/data given. This worked well rather than using chart paper.
13	well if they wanted to see actual pictures of how shapes come together to form buildings or objects you were able to pull out actual pictures. Having all the notes done head of time and being able to just pull down the answers. Students enjoy getting up there and writing on the board or being able to drag and drop things.

Do you find the interactive whiteboard helpful for differentiating instruction and/or as an assistive technology in your classroom?

1	Yes it is. If you set up various activities addressing a common theme, the interactive whiteboard can be one of the activities that students can access. On a regular basis, the interactive whiteboard is left on and students go up on their own to attempt questions. Especially useful when working with algebra tiles -- students like the infinite cloner option instead of the manipulatives available at their desks.
2	-yes - mirrors the applied workbook so students can follow and stay focused -some activities offer choice
3	With the assistive technology yes but not really for DI.
4	Most certainly, it is like a chalkboard that has come alive. Students can come to the board and manipulate it to the lesson they require. They feel more in control of their learning. It is so easy to demonstrate various ways to solve given math problems. We have even gone to the "net" to solve some of our problems that's involve outside information.
5	We often use interactive programming on the Smartboard and then head to the computer lab for students to try thing out for themselves. When struggling students are able to watch students use the tools/programs - and then attempt similar problems themselves, it increases their own confidence immensely. I encourage students of all ability levels to get to the front of the room and interact with the smartboard - with a very supportive community of learners - this works very well!
6	Absolutely very visual for those learner games allow kinesthetic learners opportunity
7	It is an excellent tool for differentiating instruction simply do to the fact that technology is what kids know and understand. They are more interested because of the hands on aspect and wow factor of the software that can be used or linked with the hardware.
8	I prefer to partner a strong student with a weaker student. Often the weaker student is also able to assist the stronger student using the tools to draw and label the question to complete.
9	not really. it does allow for different ways to present information for different learning styles
10	Its no so much that I see a difference in the differentiating but instead as an assistive technology I see huge improvement. The class is more engaged.
11	Quite helpful, information is easy to manipulate and VERY visual!
12	Yes. Students who are having more difficulty with a concept can benefit from Smart Tools or any sites that can be used interactively to help form/consolidate understanding.
13	It provides an alternative view for looking at things. Allows students to help each other out and demonstrate their solutions and ideas.
14	Well for assistive technology yes. its easier to get them to participate in class.

Describe any challenge(s) that you feel have reduced the usefulness of the interactive whiteboard in supporting student learning. How could those challenge(s) be reduced?

1	I can't think of any at the moment.
2	-the teacher learning curve - takes many months to effectively prepare and present good lessons using the full functionality of the board and software
3	Wish I had the math tools. Only had a one month trial version.
4	I guess having enough time to explore all that smart Technology has to offer. I am continuously discovering more about this awesome tool.
5	The new mathematics tools (protractor, ruler etc) are challenging me a little bit, as I've never had any training with them. The ruler, in particular, as it shrinks and grows when we move it - means that creating congruent and similar shapes is challenging. It is confusing for students (and teachers!) that the units on the ruler change. The fact that the table cannot be moved after it has been created has caused some problems as well.
6	Everyone seems to want a turn!!!But it can only be accessed by one person at a time. Tablets in the classroom that could be linked so groups could display their work together would be great.
7	I find the whiteboard is an excellent math tool when it is used with math manipulatives for the remainder of the students to complete the questions while 2 students are completing the question on the whiteboard.
8	lack of training and support materials lack of time to share new ideas with colleagues and to gain some of their expertise in return
9	I think I need to see more applications in use. I have lots of desire to try new things with the math but don't always have the time to find or learn about them. We could fix these challenges by having teachers share with each other the ways they use the board and also attend any workshops that might assist in furthering knowledge.
10	TIME TO EXPLORE FEATURES AND APPLICATIONS IS THE MOST SIGNIFICANT OBSTACLE TO MAXIMIZING USE. The cost of replacing light bulbs Seems to me to be a bit of a money grab: 400 bucks...really?
11	The challenged I face is usage of time of the interactive whiteboard as I do not have one my classroom.
12	well sometimes I feel its the same as writing on a black board but just color full. if we had more programs or games that are interactive for students. and would teach them math at the same time would be a good use of the tool.

Describe an instance when you have had a problem or question about using interactive whiteboards. How did you solve/answer it?

1	This semester, the interactive whiteboard was not connecting properly with my laptop. So I had to use the programs through my computer instead. I spoke to a few colleagues and one mentioned how he used a different port on the computer and then it worked. I didn't have the problem last year so I was a little confused, but I was quite ecstatic when I could use the board properly with my students and their excitement grew as well.
2	-in the beginning - daily...used colleagues to help trouble shoot -participated in a writing project for lessons converted to SMART Notebook - learned soooo much
3	Asked a colleague
4	The markers would not work one day. I contacted IT Dept. in our board and it was fixed (new marker holder) within days. :)
5	Any time I have difficulty with a feature of my Smartboard, the students and I work together to figure out a solution. We do a lot of trial and error approach to learning about the Smartboard.
6	called a colleague
7	No problems to date!!!
8	I emailed out Board Whiteboard consultant, who was able to come to my class and to give a workshop for my colleagues in order to better understand how to use it successfully.
9	asked a colleague
10	I had several technical questions about the smartboard and was able to get online and have a smart board representative chat online with me to resolve the answer. I also was unsure of how to clean it and they helped me as well. I really want to learn more about capturing or using video but am not sure where to look.
11	Light bulb issue: it took several visits from our IT department and a couple calls to Smart Technologies. The process took about six weeks. The product required a new light bulb assembly.
12	Any problems/questions generally are handled through the school with colleagues.
13	When first starting with the SMARTboard, I could not get it to work on my laptop, but I asked a co-worker and she helped me.
14	figure it out on my own 90 percent of the time since I am some what familiar with computers. Rest of the time ask some one who used it last year or read the manual.

Describe an instance when you shared a way of using interactive whiteboards with colleagues.

1	I am a 'go-to' person with regard to using interactive whiteboards in my classroom. I have helped colleagues with very basic needs (how to get the board working) to incorporating internet links.
2	-still happens regularly - as one of us learns something interesting or new we share with others -have found that you can only learn new things every once in a while and use them before you remember how to use them regularly
3	Shared all of my ready made smartboard files and helped science department see the usefulness of the smartboard and how it could be used in science.
4	I showed two of my colleagues how to use graphing tools. We have just received a magic eye (camera) for the smartboard and one of our colleagues has been showing us how it works. Students are able to show their hard copy work on the board, and for hands on demonstrations. We are very lucky to have a number of smartboards in our wing of the school, and the students are reaping the benefits.
5	We use the Smartboard in my classroom for staff meetings, we meet with like-grade classes to share information on the Smartboard. I have demonstrated many many math strategies with the Smartboard, as I am one of the only teachers lucky enough to have one in my classroom. I honestly don't know how I would teach mathematics without a Smartboard anymore!
6	explain how to create links and showed colleague the educational resource bank
7	I was able to help a colleague use the software that is interactive and preloaded in the computer. I was also able to show that same teacher how to use the smart community/lessons that can be accessed to use in his classroom.
8	I organized a workshop to help us better understand how to fully implement the use of math tools.
9	we haven't really had an opportunity to get together and share our ideas
10	I have the only smart board in the school. I have helped a teacher input some work for a French read aloud with her students. I had it open for her to use. She also came in to so some singing activities and used Google Earth to show her students (grade 2) where a certain area was.
11	Down loading maps of WWII battle sites and having the history teacher draw battle plans and strategies on the battle field areas.
12	I shared my knowledge of Smart Tools with a Grade 1/2 teacher for her math lesson on patterning.
13	I used to help teachers with the technical aspects of the software. how to change things or add things or using it the way wanted to.

APPENDIX C

CLASSROOM OBSERVATION PROTOCOL FOR THE USE OF TECHNOLOGY

CLASSROOM OBSERVATION TEMPLATE – USE OF TECHNOLOGY

SCHOOL: ______________________ **TEACHER:** ___________________ **DATE:** ________

GRADE: _____ **COURSE:**_____________ **START TIME:** _________ **END TIME:** _______

SKETCH OF CLASSROOM:

INDICATE: DESK ARRANGEMENT, # MALE STUDENTS, # FEMALE STUDENTS, # ADULTS, LOCATION OF TECHNOLOGY ETC.

PHOTOS TAKEN (CIRCLE ALL THAT APPLY):

FRONT WALL **REAR WALL**

LEFT SIDE WALL **RIGHT SIDE WALL**

OTHER: ____

MATERIALS USED DURING THIS LESSON (CIRCLE ALL THAT APPLY):

INTERACTIVE WHITEBOARD (SMARTBOARD) **WHITEBOARD**

CHALKBOARD **TEXTBOOKS**

STUDENT WORKBOOKS **WORKSHEETS/HANDOUTS**

GRAPHING CALCULATORS **CALCULATORS** **LAPTOPS**

IPODS/MEDIA PLAYERS

MANIPULATIVES (SPECIFY); ____

OTHER: ____

SOFTWARE USED DURING THIS LESSON (CIRCLE ALL THAT APPLY):

SMART NOTEBOOK **MS WORD** **EXCEL**

POWERPOINT **TI SMARTVIEW (TI EMULATOR)**

TI-NSPIRE TEACHER EDITION **COMPUTER ALBEBRA SYSTEM (CAS)**

GIZMOS (SIMULATIONS) **GEOMETER'S SKETCHPAD**

TINKERPLOTS **FATHOM**

OTHER: ____

WEB-BASED RESOURCES USED DURING THIS LESSON (CIRCLE ALL THAT APPLY):

WEBSITES (SPECIFY):____

ONLINE VIDEO (SPECIFY):____

SOCIAL MEDA (SPECIFY):____

INTERACTIVE FLASH APPS (SPECIFY): _________________________________

OTHER: ____

DESCRIPTIVE NOTES:

TIME (10 MIN SEGMENTS)	DETAILIED DESCRIPTION OF THE SEQUENCE OF ACTIVITIES (INCLUDE QUESTIONS ASKED BY TEACHERS & STUDENTS, RESPONSES TO QUESTIONS, STUDENT GROUPINGS, MATERIALS USED ETC.)

TIME (10 MIN SEGMENTS)	**DETAILIED DESCRIPTION OF THE SEQUENCE OF ACTIVITIES (INCLUDE QUESTIONS ASKED BY TEACHERS & STUDENTS, RESPONSES TO QUESTIONS, STUDENT GROUPINGS, MATERIALS USED ETC.)**

OTHER NOTES &/OR CLARIFICATIONS NEEDED FOR FOLLOW-UP INTERVIEW:

NAME OF RESEARCHER(S): ______________________________

RELATED AUDIO, VIDEO & IMAGE FILES:

____

____

COLLECTED CLASSROOM MATERIALS (WORKSHEETS, HANDOUTS, ETC.):

____

____

APPENDIX D

FOLLOW-UP TEACHER INTERVIEW PROTOCOL FOR THE USE OF SMART BOARDS

Follow-up Teacher Interview Protocol for Use of SMART Boards

Project: Using New Technologies in Intermediate Classrooms

These questions serve as a general guide for the short (approx.30 min.) debriefing conversations that follow each classroom observation session. The protocol contains questions on general themes that will be addressed but additional questions will emerge in relation to specific classroom observations and from the responses of participants.

- What do you see as the role of technology in your classroom practice?
- Could you describe your goals for how the SMART Board was used in this lesson? Was the technology useful in the way you had expected?
- Did the students use the SMART Board in the ways you expected them to or were there any surprises? Could you describe any unintended ways the technology was used?
- How do you feel that using the SMART Board enabled you to address the different needs of students in your class?
- How do you balance the need for technical SMART Board skills with the mathematical thinking goals you have for your students?
- What resources and supports have you found helpful as you began to incorporate the SMART Board into your classroom practice?
- What challenges have you encountered as you began to incorporate the SMART Board into your classroom practice?
- Are there any resources or supports that you feel would help you to further incorporate the SMART Board into your classroom practice?

APPENDIX E

USING OPEN SPACE TECHNOLOGY AS A RESEARCH METHOD

Using Open Space Technology as a Research Method

Martha J. Koch, Ph.D.
Faculty of Education, University of Ottawa

Open Space Technology is emerging as a valuable method of collecting data in educational research projects. My application of open space concepts to data gathering is based on principles of Open Space Technology (Owen, 2008) and Open Space Learning (Monk, 2011). In my experience, this approach to data gathering can facilitate the inclusion of multiple perspectives, create conditions for the emergence of issues and themes from participants rather than researchers and encourage engagement with complex issues at a variety of levels.

Open Space Technology

Open Space Technology began as a means of facilitating more effective and productive meetings (Owen, 2008). This facilitation strategy has been used for more than 20 years in 124 countries with groups ranging from 5 to more than 200 participants (Owen, 2008). Open Space Technology has been used in a variety of contexts including strategic planning, community organization, and professional development and is reported to be particularly effective when working with diverse groups of people, complex issues, and issues where conflicting perspectives are anticipated (Owen, 2008).

While Open Space Technology is an inherently flexible approach, it most often begins with participants seated in a circle or semi-circle leaving an open space at the centre. A blank wall adjacent to the seating area becomes a bulletin board used by the participants to communicate and explore ideas. Each participant is invited to post an issue or idea related to the topic of the session. After reviewing the posted ideas or issues, participants self-organize into discussion or working groups on a topic of interest to them. In this manner, everyone attending the session has a role in creating the agenda for the session. Participants are given the option to move between discussion groups and to contribute ideas as they see fit.

Open Space Technology is a flexible, dynamic and generative process that can help to ensure that all participants in a session have a voice. An example of the use of Open Space Technology as a form of professional development is the National Education Association in the US who gathered 420 teachers, school board members and administrators for a one-day conference where they created and self-managed 85 workshops (Owen, 2008).

Open Space Learning

Open Space Learning (OSL) is an approach that is increasingly being used in higher education contexts, particularly in the UK, in a range of disciplines including English, philosophy, chemistry, law and business (Monk, 2011). Rather than passive listeners, in OSL students are active participants in the discovery and creation of knowledge. OSL as a pedagogy follows a "workshop" approach and is typically conducted in open spaces without the rigid hierarchical arrangements evident in lecture theatres and many classrooms. Through the open and free exchange of ideas, students are able to acquire, practice and develop a range of skills. This approach to learning enables participants to collaborate meaningfully in the acquisition of knowledge and can encourage those who may have been reluctant to engage in conversation in a traditional classroom setting to participate more fully.

Using Open Space Approaches in Research

A few examples of the use of open space approaches in research can be found in the literature. These examples include a variety of research topics and involve participants at a range of ages.

For instance, Wang (2009) used an open space approach with 83 undergraduate university students in Taiwan who were taking an intermediate level English class. Results from this study suggest increases in students' interest in class participation, in the opportunity for students to have their voices heard, and in their overall level of satisfaction with the course that included open space approaches as compared with courses where open space was not used. In another example, Allan et al (2009) successfully used an open space technology approach as a method of data collection and a means of conducting a discussion with children and young people about diversity and disability.

More closely connected to the Canadian educational research context, Suurtamm & Graves (2007) used an open space approach to gather the views of Ontario leaders in mathematics education about the implementation of the intermediate mathematics curriculum.[1] A group of approximately 25 participants posted issues or topics of concern to them and then self-organized into three discussion groups which were focused on assessment, teachers use of tools and strategies to teach mathematics and the role of mathematics processes in the curriculum. Importantly, the participants themselves generated the topics for discussion rather than topics being chosen *a priori* by the researchers.

Some Suggestions

Based on the open space literature and previous experience using this approach for data gathering, a few suggestions for implementing this approach are offered. Researchers are advised to begin the session with a focused but open-ended prompt for participants to respond to. The goal is to create a prompt that will result in discussions that are clearly relevant to the topic of the research but to avoid prompts that incline or restrict participants to a specific perspective.

Once the participants have responded to the initial prompt and have self-organized into discussion groups, it is important to strike a balance between leaving groups space to talk without you being too close and dropping by from time to time so that they are convinced of your interest.

In addition, it is important to encourage discussion groups to record their comments, discussion, and observations. Both adolescent and adult participants need frequent reminders and encouragement to record what transpires within their discussion group. Chart paper and markers can be used as a method of recording but, depending on the comfort level of the participants, audio recording may also be useful.

[1] As a research assistant on this project, I had the opportunity to assist with this Open Space Technology session and to participate in the analysis of the data that was gathered.

Finally, as the session draws to an end it is important to allow time for the full group of participants to debrief and share some of the ideas that emerged from their discussion groups. This debriefing is particularly valuable if participants were not able to move from one group to another during the open space session.

References

Allan, J., Smyth, G., l'Anson, J. & Mott, J. (2009) Understanding disability with children's social capital. *Journal of Research in Special Needs Education* 9(2), 115-121.

Monk, N. (2011). Open-Space Learning
http://www2.warwick.ac.uk/fac/cross_fac/capital/lightbox/player.swf?url=http://www2.warwick.ac.uk/fac/cross_fac/capital/003open-space_learning_1.flv
University of Warwick Accessed May 24, 2011.

Owen, H. (2008) Open Space Technology: A User's Guide. San Francisco, CA: Berrett-Koehler Publishers.

Suurtamm, C., & Graves, B. (2007). *Curriculum Implementation in Intermediate Math (CIIM) [Research Report, Year 1]*. Ottawa, Ontario, Canada: Faculty of Education, University of Ottawa.

Wang, Y. (2009). Open space learning circle and active learning in English communication class. *European Journal of Social Sciences* 11(3), 477-485.

APPENDIX F

CLASSROOM RESPONSE SYSTEM (“CLICKER”) DATA

Classroom Response "Clicker" System
Questions & Responses

If I could only have one digital device I would choose?

iPod/Mp3 player	21%	4
Laptop	11%	2
Cellphone	47%	9
iPad/Tablet/Netbook	21%	4
	Total:	19

I have used a SMART Board…

Only in this class / for math in earlier grades	37%	7
In several subjects this school year / in earlier grades	63%	12
	Total:	19

I feel the SMART Board has…

Helped my math learning	58%	11
Made my math learning more difficult	11%	2
Had no impact on my math learning	21%	4
Not sure/no opinion	11%	2
	Total:	19

SMART Boards should be in all math classrooms

Strongly agree	74%	14
Agree	11%	2
Neutral	11%	2
Disagree	0%	0
Strongly disagree	5%	1
	Total:	19

APPENDIX G

TEACHER FOCUS GROUP PROTOCOL FOR USE OF IPODS

Focus Group on Using iPods in Secondary Classrooms

Overview

After asking participants to introduce themselves, we will pose an open-ended question asking each participant to describe his or her use of iPods in the classroom. More specific questions, as indicated below, will be asked depending on the details participants include in their response to the initial prompt. Through this process we will get a sense of a range of issues associated with the use of iPods beyond those that may have been identified in previous research. This protocol is based on the recommendations of Seidman (2006).

Introduction

Please provide your name, the school you teach at and the grades, subjects and levels you are currently teaching.

Open-ended prompt

As you know from the consent form, the main focus of this research is to get a better understanding of how teachers are using iPods in intermediate classrooms. To begin the focus group, we would like to ask each of you to describe how you are using iPods in your classroom this year. Once each of you has had a chance to describe what you are doing, we will have a conversation where you can talk about your experiences using this technology.

Additional prompts

- *What were some key supports that helped you acquire the iPods and integrate them in your program?*
- *What are some of the challenges you have encountered in using iPods in your program?*
- *What other tools and/or resources do you use along with the iPods in your program?*
- *Have you had any feedback or reactions from parents?*
- *What resources have you found helpful in developing this iPod program?*
- *What is your perception of the impact of this technology on your students' learning?*
- *Are there specific students or groups of students for whom you have found this technology to be particularly valuable?*
- *Are you using this technology as an assistive device for some students?*
- *Have you found collaboration with other teachers to be helpful in this project?*

Closing prompt

Are there any other comments you would like to make about using iPods in the classroom?

Final Remarks

Thank you for participating. After we leave you may think of other comments you would like to make about this topic. If you do, please feel free to get in touch with Martha Koch using the contact information provided on the consent form.