0.1 Measure 2: the value of interactive whiteboard technology in supporting teacher practice and student mathematics achievement

The change in teachers' effectiveness in math instruction specifically facilitated by SMART Boards and Smart technology was measured via **surveys**, a review of **SMART Notebook files** (produced by both teachers and students), **observations**, **journals**, and **participation in electric electronic conference**

0.1.1 Results of Measure 2 – survey and qualitative data

Survey results

Teachers were asked to indicate the degree to which SMART Boards were used in their classrooms:

Teachers' involvement with SMART Board technology was significant, with over 90 per cent of teachers using the board every day to teach, and every teacher involved (100 per cent of respondents) using a SMART Board to teach the daily math lessons.

Teachers were also asked a number of broad questions about the use of SMART Boards at the school:

1) How has the presence of a SMART Board impacted math instruction in your classroom?

Teachers identified a number of benefits that the SMART Boards and SMART notebook technology brought to their classroom practice.

- More/better use of examples to demonstrate geometry concepts.
  "Students were able to see what it looks like when they are finding the volume of a figure. It became real because they saw the 3D shapes on the board – they connected!"

  "During a math lesson on 3D shapes, where the focus was on determining the number of faces, edges and vertices, I was able to use the SMART Board to explicitly show the students each of these concepts."

  "Teaching 2D geometry, clarifying that position does not change the properties, size does not change the properties – students use rotation, etc, on the board to clarify that properties remain the same."

  "I love the math tools of the software. I was doing a geometry lesson on slides, flips and turns. It

was awesome. It's difficult to do this on a blackboard of with an overhead".

- Teachers expressed particular approval for the protractor tool, mentioning it often:

"Can make the angles larger, move the angles for measurement, etc"

"Interactive Protractor! Fantastic Feature! ...[on the] final assignment of the week over 90 per cent used it correctly!"

"Math lessons are much easier to model and have kids follow along with their own manipulatives."

- Teachers found it easier to teach number and numeration concepts, such as place value, decimals, etc.

"infinite cloner ,mumber lines really helped"

"...students were having difficulty [until] I had two students up at the board working on place value – it was great seeing the 'light bulbs' go off in their heads and [they] were able to successfully complete the follow up work.

Using place value chart to model multiplication of decimal numbers by a whole number – the infinite cloner was super for this. This process really got the students to understand the regrouping process…I heard a lot of "ahhh…I get it!". Before they had just memorized a procedure, so errors in regrouping occurred due to lack of understanding. Now, many seem to see why we "carry" a certain number when multiplying with regrouping. The visuals and the actual moving/trading really helped drive the concept home.

- Teachers also he visuals and the actual moving/trading really help drive the concept home – regrouping.

The grid paper was really useful in teaching geometry and area and perimeter

In algebra – easier to move the missing variables around

"We've been working on algebra, and it was very useful to be able to move the missing variables around…students seem to be able to understand much more clearly."

Tools really help children understand symmetry, folding and congruency

"I did a math lesson on angles today on the board. It was so fantastic! ... the kids really seem to get it. I remember doing lessons in the past prior to the SMART Board and it was so difficult! ... [it's] great for Special Education students (especially)!!!"

"The manipulatives and smart boards have changed [my] instruction drastically

With the SMART Board, I find my lessons are more organized and effective and my lessons are visible.

"I am able to quickly change the objects when sorting on a Venn diagram, and use different sorting rules. "

How has the presence of a SMART Board impacted students' learning?

Teachers reported that by the end of the project, students were:

- Enjoying math more and/or were more engaged during math lessons.
- Students have a clearer understanding of visual concepts
- Students have a better understanding of core math concepts

Notebooks

The SparkPlug project team reviewed notebook files from both teachers and students for evidence of teachers' use of the tools and strategies highlighted in various SparkPlug sessions.

Teacher Notebook files

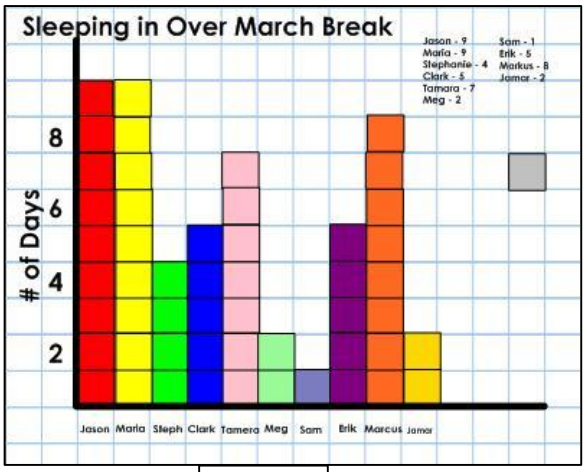
Teacher notebooks demonstrated a rich variety of strategic use of the tools available through SMART Notebook.

The SparkPlug team analyzed teacher notebooks for evidence of improved explanatory power (i.e., clear explanations of mathematics subject matter in ways that are superior to those possible through more traditional blackboard technology).

Listed below are some examples of how the teachers used SMART notebook tools to support their instruction of mathematics;

Data Management & Probability

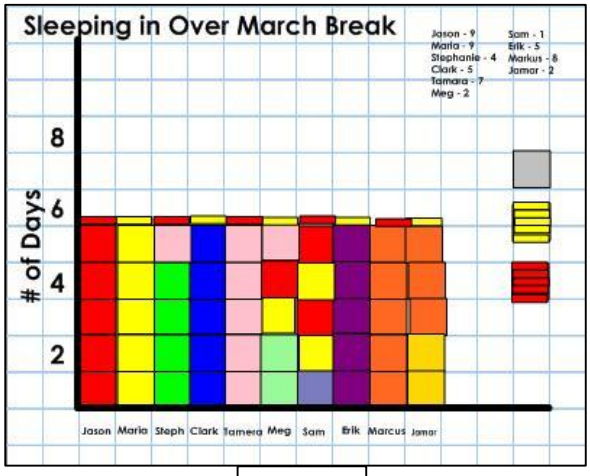
One teacher described students' creation of a graph using concrete manipulatives stacked on a table. The students transferred this concrete graph into a bar graph on the SMART Board using the infinite cloner with the grey square and the fill tool. See Fig. DMP1 below.



DMP1

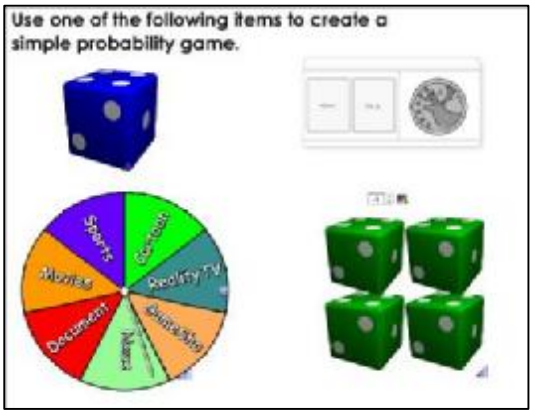
The teacher then introduced the concept of “average”. To find the average number of days that they slept in over the March Break, students “leveled” the data by manipulating the physical cubes and squares. When they found that there was a remainder of two days, students abandoned the concrete model and went to the SMART Board. The students then divided those remaining squares into fractional amounts and leveled those amounts to show the average. The colours helped students to track how they manipulated the data to find an average value.

See Fig. DMP-2.



DMP2

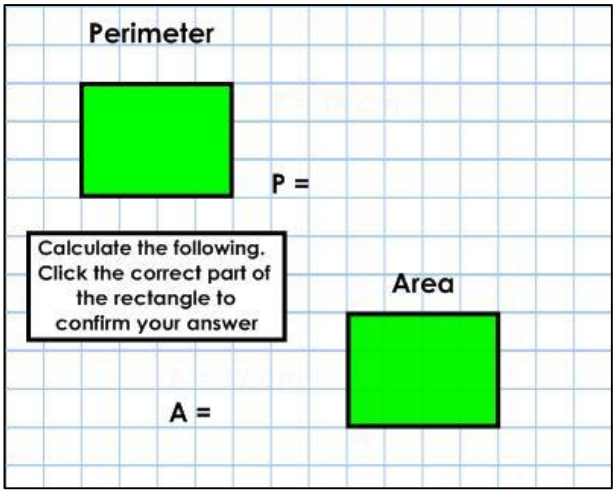
Teachers reported that they made use of SMART Notebook software during several interactive activities when teaching probability. The SMART technology allowed teachers to involve the entire group, as opposed to more traditional teaching tools, (e.g. l coin toss, dice roll or spinner) more limiting in terms of large group involvement.



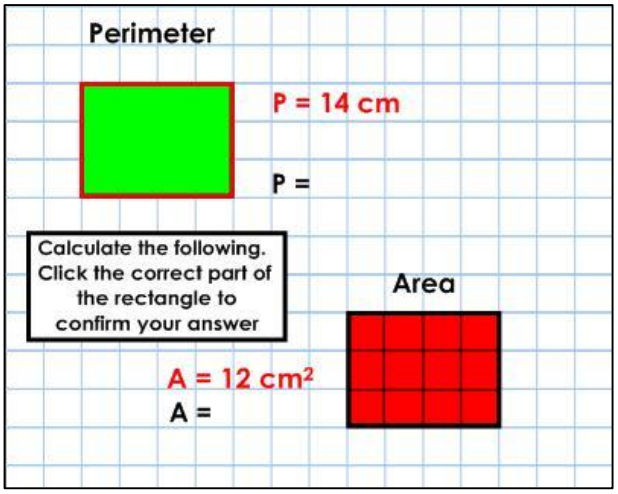
Measurement

One teacher made use of the animation features embedded in the software to enable students to check their own work. Students were asked to calculate the perimeter and area for a rectangle. Once the students had written their answers down, they were able to move part of the rectangle to reveal the answer.

Figures M1 and M2 below show how the green box can be removed to enable students to see the correct "area" of the rectangle.



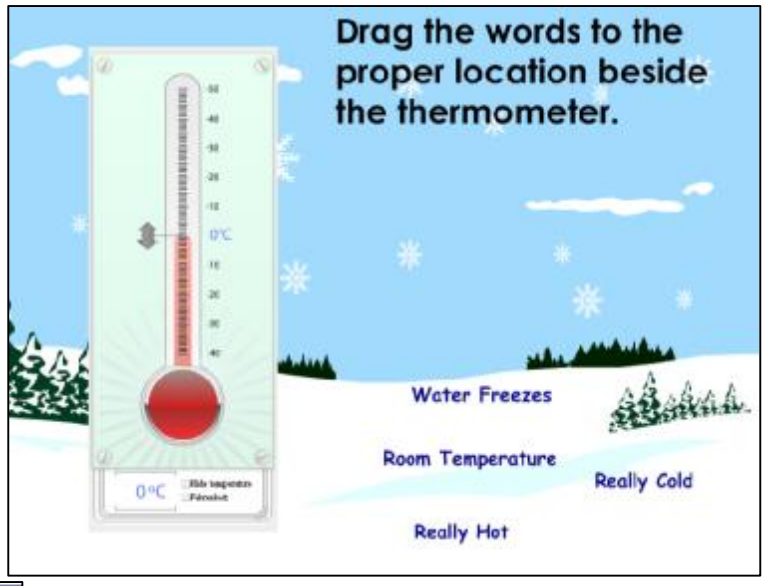
M1

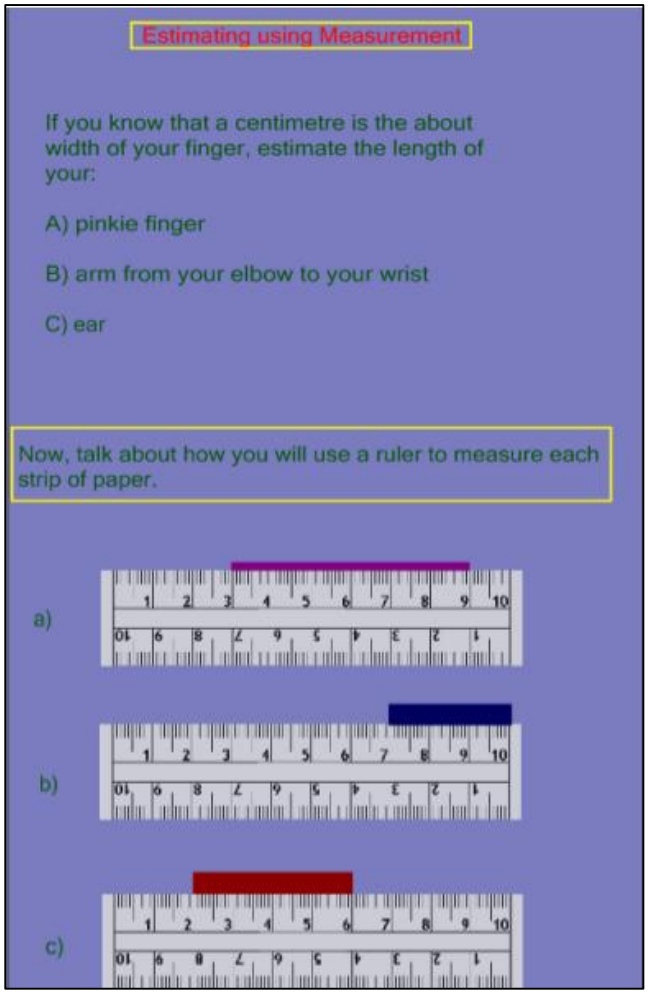


M2

Teachers also made use of SMART software help students understand the physical meaning of “temperature.” Using the SMART Board, students could manipulate an interactive thermometer to match the descriptions provided (e.g. “water freezes”, “really hot”, etc.)

See fig. M3 at right.



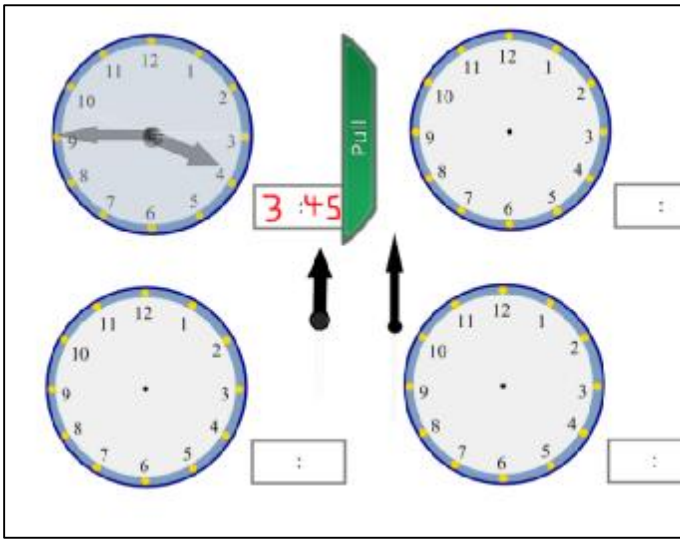


Teachers were also able to use the SMART Board to demonstrate the use of common measurement tools.

In the example slide at right (Fig. M4), a teacher used items taken from the software gallery to demonstrate the use of the ruler to measure objects when they are not lined up to the zero line. The ruler is clearly visible to the entire class – something that can be a challenge when demonstrating measurement tools to large groups of students using more traditional teaching aids.

SMART Notebook software enabled teachers to build customized activities quickly and easily The ease of activity creation enabled the teacher to give each student a unique problem (eliminating the temptation to copy, etc.).

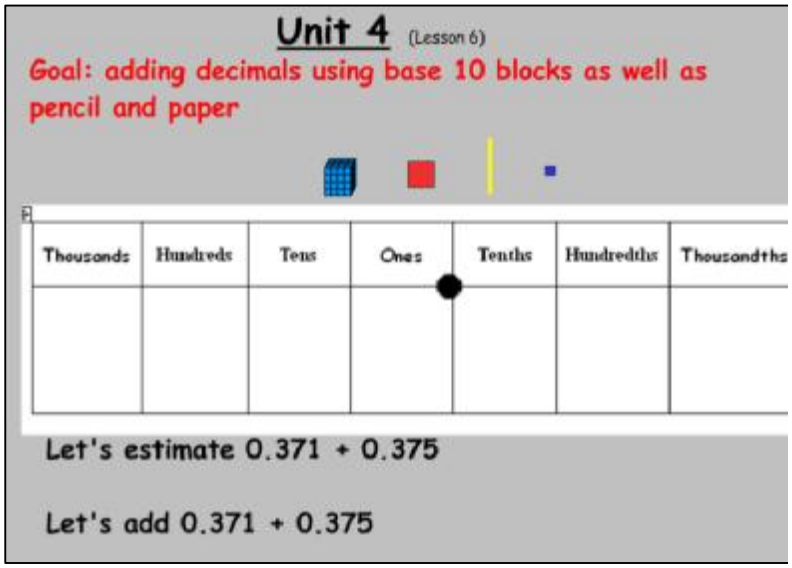
In the activity pictured at right (fig. M5) the teachers provides the time, and students place the clock hands in the proper position. The teacher can also set the hands and ask students to record the time. In this case, the teacher created a self-checking clock that can be superimposed onto the student's clock to let the students see if they have positioned the hands correctly.



Number Sense and Numeration

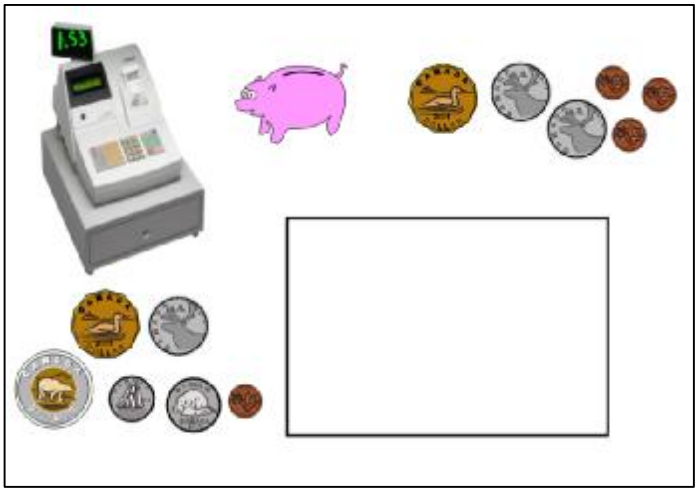
Teachers learned to make effective use of interactive whiteboards in the teaching of number sense and numeration.

The example at right (fig. NSN1) enables students to construct visual representations of various numbers (e.g. thousands, tenths, etc) This lesson uses the base ten blocks available in the SMART Notebook gallery. Using the infinite cloner and chart on the board, students can build the numbers below and add them together.



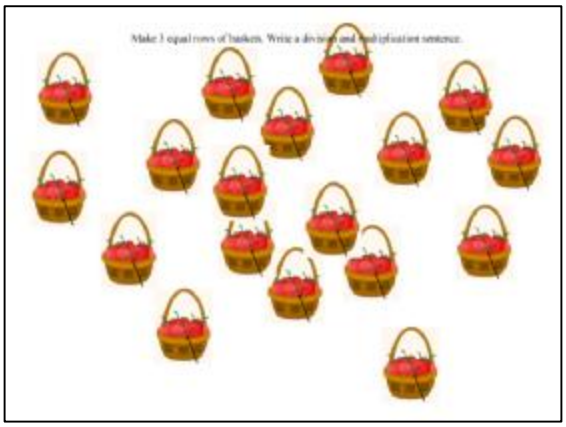
Coins are another area where SMART Boards enable clear demonstrations using manipulatives.

An example of a teacher-created notebook file is depicted at right in fig. NSN2. This page uses coins from the Notebook software gallery and provides a workspace where students can build the amount of $1.53 using the coins provided under the cash register. Students are able to check their answer by dragging the piggy bank to the left which is hiding one of the solutions off the screen (shown here with the solution visible).



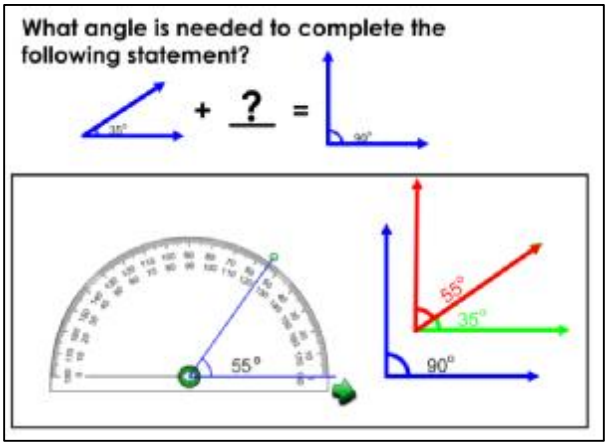
Interactive whiteboard technology also enables students to manipulate object to form mathematical structures such as arrays.

Students can easily move the images into an array and logically deduce the multiplication and division sentences that result.

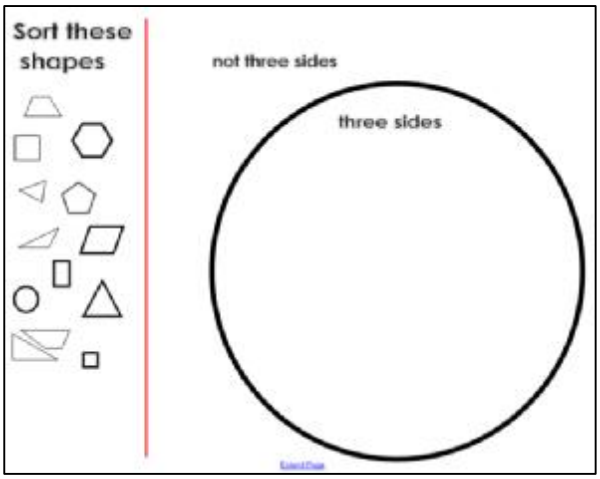


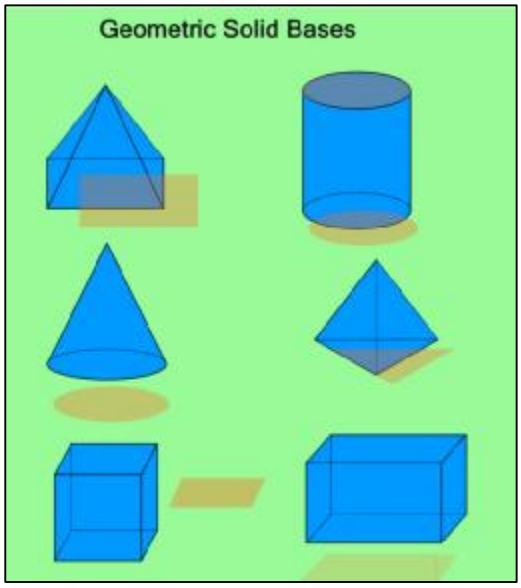
Geometry

The interactive protractor was one of the tools most commonly referenced by teachers, as the manipulative demonstrated by the teacher closely matches the tool used by students. In Figure G1 at right, a teacher created a lesson which enabled students to see the size of the angle increase as the arm moves, and output an answer to check their work.



Notebook software contains several programmed shapes that enable teachers to draw useful shapes quickly and easily. Figure G2, right, shows an activity where students can classify shapes based on their attributes (e.g. does or does not have three sides).





Many students have difficulty understanding pictorial representations of three dimensional figures.

The slide at left (fig. G3) demonstrates an activity where students can connect the shapes to shadows to help them understand the three dimensional shapes they are studying. Students can move the figures around to experiment with the different shadow figures.

Patterning and Algebra

Many teachers identified the interactive "hundred" chart as a powerful tool for exploring patterns. In the example at right (fig. PA1), students identified columns, rows and diagonals using different colours.

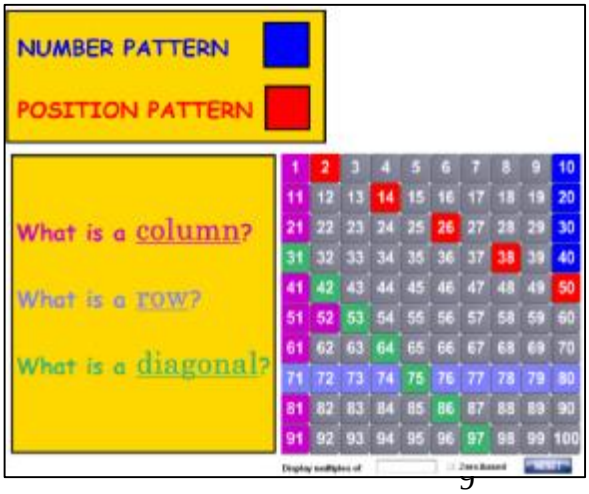
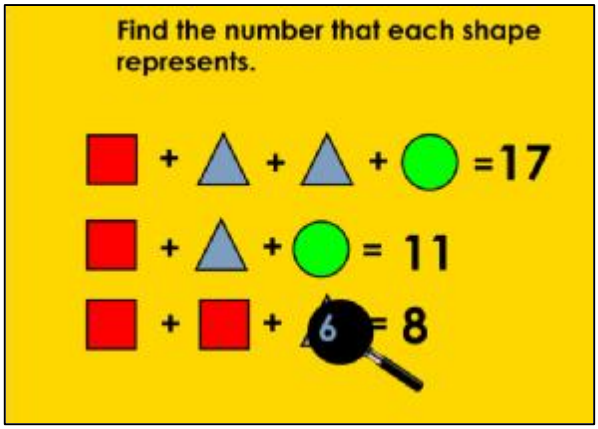


Figure PA2 shows an algebra problem with the unknown quanitites represented by polygons instead of algebraic figures. Students were asked to deduce the number represented each shape. Students were able to check their answers using the magnifying glass to reveal hidden numbers.



Student Notebook files

Teachers with SMART Boards in their classroom were also encouraged to give their students the opportunity to create SMART notebook files for use in the classroom.

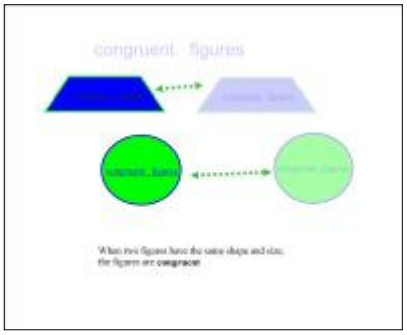
Students used the SMART software to create their own math journal notebooks on school computers. These journals gave students the opportunity to display their own knowledge on a topic on which they were working on in class. Students were able to share their notebooks and math knowledge with their peers in class as well as with their parents at home (SMART software is downloadable).

The notebook software enabled students to easily create high-quality slides: all of the slides presented below were created by students in grades three and six.

Teachers were asked to submit examples of student-created notebook files to the SparkPlug team. The examples included in this section are examples of how students used the tools to help demonstrate difficult concepts.

GEOMETRY

Student notebook files demonstrated a variety of mathematics concepts using the tools available.

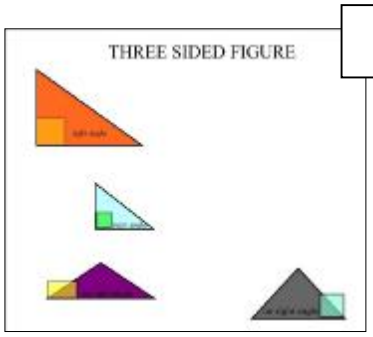


Congruency

The slide to the left (SN1) demonstrates a student's use of the transparency tool to show congruence between shapes. The use of semi-transparent shapes allowed students slide the shapes over one another, seeing both

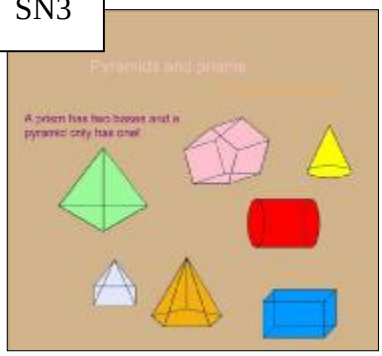
simultaneously while they are aligned – this is much more difficult to show using paper manipulatives.

SN2



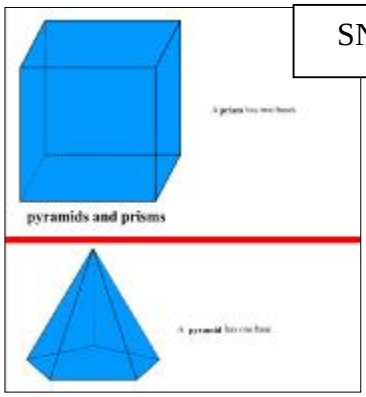
Right Angles
In the slide at right (SN2), a student used the shape tool and transparency tool to create a rectangle/square to demonstrate right angles in triangles.

SN3



Students used the gallery to find objects that they could use to show the difference between pyramids and prisms (SN3 and SN4).

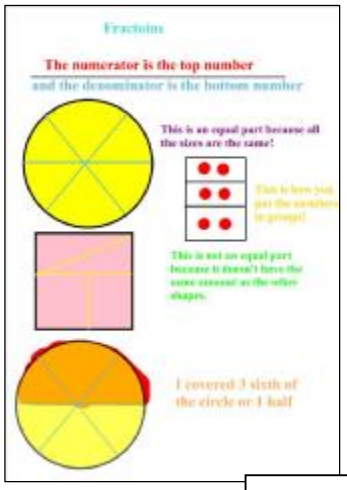
SN4



NUMBER SENSE

Students used images from the notebook software's gallery – in this case, coins – along with the infinite cloner tool to solve problems related to money and making change (fig. SN5). The teacher submitting this file indicated that incorrect solutions were used as an opportunity for class discussion.

SN5



SN6

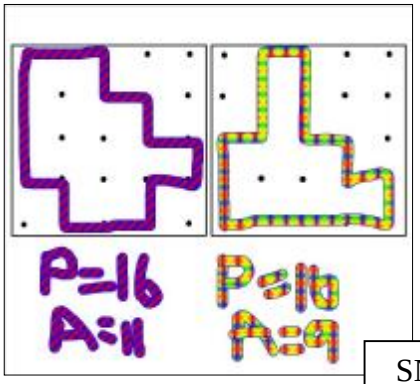
This student used shape, line, transparency, pen and colour to display knowledge of fractions (Fig. SN6).

MEASUREMENT

Students used clocks and images with moveable hands to demonstrate an understanding of time (fig. SN7)

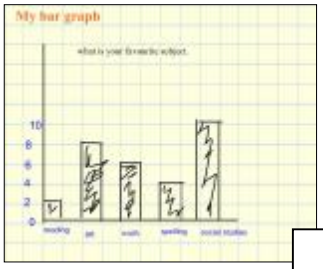
SN7

Students used tools to show shapes. In fig. SN8 (below), a student used a "virtual geoboard" background and a "creative pen" to create shapes with the same perimeter but different area.



SN8

DATA MANAGEMENT



Students were also able to create charts and graphics to display information.

SN9

"Notebook can be installed on all computers – Yahoow."

Teacher Journals

The Sparkplug project provided journals to teachers participating in the math-technology stream; teachers were asked to record their experiences during the SparkPlug project. Specifically, teachers were asked to document the process of the incorporation of SMART Boards into their classroom practice – paying particular attention to their various challenges and successes throughout the course of the SparkPlug project.

In general, the early journal entries concentrated along two main themes:

- Frustration with technology
- Excitement about the potential of the initiative and the technology.

Some of the specific frustrations regarding technology expressed by teachers included difficulty with:

- Writing by hand on the SMART Board and changing it to typed work.
- Learning how to use the gallery.
- Learning how to use different tools.
- Accessing contacts and websites.
- Learning how to align.
- Sharing sessions online.
- The care of the equipment.
- The [SMART Notebook] toolbar
- [Not being able to] spend [more] time with a SMART Board lead teacher

"I am just a beginner. I must purposely plan to use it. However, with more regular use I am starting to see how it can be easily integrated into every day instruction."

Teachers' journals also expressed positive feedback regarding early successes in incorporating interactive whiteboard technology into their classrooms. Some examples of the feedback recorded in teachers' journals included:

- Learning the usefulness of the undo button
- Learning how to make graphs, calendars, etc
- Learning to access pre-made lessons on the Smart website

Teachers also included some generally positive comments highlighting some of the benefits of the technology:

- Great for group work – they can all take part.
- No photocopying.
- Helps organize your lesson.
- Allows you to repeat lesson – or have students review lessons on their own.

"It isn't really hard to learn how to use the board"

SMART Technology: facilitation via the internet

Teachers said that SMART Boards and SMART technology enabled teachers to present resources available via the internet more easily and effectively in their classrooms.

Teachers expressed significant support for the advantages of the technology over other classroom presentation techniques (e.g. blackboards, PowerPoint slides/projectors.

"This is an amazing tool – where has it been all my life?"

Some of the resources identified by the teachers included:

- EQAO questions
- § Ministry resources
- § Other teachers' notebooks
- § Lessons from websites
- § Session notebook files from SparkPlug project
- § Model lessons from the SMART website
- § Internet sites (e.g. virtual teaching library)

Please see Appendix XXX ("How has technology supported your instruction of mathematics") for more detail and direct quotations from the surveys.

0.1.2 Analysis of data from Measure 2 - the value of interactive whiteboard technology in supporting teacher practice and student mathematics achievement

Teachers derived significant value from the presence of interactive white board technology in their classrooms, and identified many uses of the technology that enhanced math teaching practice.

At the end of the two-year project, the vast majority of teachers who had participated in the SparkPlug project chose to remain at the same assignment at the same schools. In teacher journals, teachers identified the presence of a SMART Board in the classroom as the primary factor in their decision to remain at the same teaching placement. Those teachers who did move to new schools lobbied their new administrators to purchase SMART Boards for their classrooms. Overall, participating teachers were nearly unanimous in their belief that SMART Boards and SMART technologies were of significant value to their teaching practice – particularly in terms of mathematics instruction.

After the close of the project, seven of the eight participating grade six level schools opted to purchase additional SMART Boards for their schools.

Among participating grade three schools, nine of the thirteen participating grade three schools purchased additional SMART Boards.

Both participating teachers and their administrators recognized the value of the techniques and tools to which teachers were introduced during the SparkPlug sessions.

Overall, educators participating in the SparkPlug project endorsed SMART Boards, SMART technology and the instructional techniques for their use presented in the SparkPlug sessions.

Surveys and Journals

The sentiments expressed by teachers were relatively constant between both surveys and journals.

Teachers expressed broad approval for interactive whiteboard technology in supporting mathematics education. Teachers documented a wide range of uses for interactive whiteboard technology in the various mathematics streams.

Teachers specifically identified a number of tools of great value in supporting their practice: geometry support tools were mentioned often – including the protractor, grids and the ability to easily manipulate shapes in three dimensions.

Teachers found that interactive whiteboard tools enabled them to demonstrate core concepts in areas such as measurement, geometry, probability, data management, numeracy, algebra and patterning more effectively and efficiently than would otherwise be possible. Teachers comment that the SMART Boards delivered significant savings in labour and preparation time, as teachers were able to reuse lessons easily as well as incorporate lesson materials from external sources. The ability to easily modify and re-teach lessons was lauded often.

Teachers also pointed to SMART technology as facilitating better organization and lesson planning.

Teachers also found that SMART technology enabled better parent-teacher-student interaction, as children were able to e-mail their work home and share it easily with their parents.

"SMART Notebook files mean that a lesson has to be created *once*, and it is then available to *all* members of the professional learning community, rather than just the local group."

Teachers commented that SMART Boards were easy to use and easy to incorporate into every day instruction.

Teachers resisted classroom transfers because they wished to continue to make use of their boards.

Teachers that made use of the

0.1.3 Factors affecting Measure 2 - the value of interactive whiteboard technology in supporting teacher practice and student mathematics achievement

The ability of the SparkPlug project to provide an accurate evaluation of the value of interactive whiteboards was impacted by a number of factors, both in negative and positive senses.

The fact that many of the issues affecting the implementation were specific to TDSB could lessen the ability of the SparkPlug project to provide an evaluation of interactive that is applicable to a generic educational context.

Conversely, the context-specific nature of many of challenges encountered during the project actually increases the relevance of the project's findings as they relate to a roll-out of interactive whiteboard technology in TDSB (and by extension, other boards with substantially similar situations).

In short, the challenges identified by the SparkPlug project are likely to be relevant for other schools and families of schools within TDSB – and by extension, the solutions developed during the course of the SparkPlug project are also likely to be relevant.

The TDSB-specific challenges encountered included logistical restrictions during set-up as well as limitations placed on the use of technology within TDSB.

Logistical restrictions during setup

- **Delays in setup**
  - There was a large delay between the arrival of the board and the time that the board was set up in the classrooms.
  - There was some confusion regarding the approval process for:
    - How to mount the board.
    - How to ensure that the power equipment met health and safety standards.
    - Restrictions placed on the teachers and schools in terms of physically mounting the boards.

- It took much longer than expected to determine the optimum placement of the interactive whiteboards in the classroom.

Learning curve associated with the use of new technology

- As mentioned above, it took longer than expected to identify the optimal classroom location for the SMART Boards.
- There was a learning curve associated with understanding the proper use
- That was a big part of the training
- Give a few brief examples (handwriting, how to use different tools, how to access online resources, learning how to access others' lessons)

- **Restrictions placed on technology usage in TDSB**
- No computers specifically designated for teachers' use.

  As teachers were forced to use computers designated for childrens' use, teachers faced limitations regarding hardware access – for example,
  - Teachers were unable to use notebook files that they had created at home because the childrens' computers had a 30 MB limit on capacity.
  - Teachers would create notebook files at home and be unable to upload them from USB keys (no access granted).