Virtual Manipulatives

on the Interactive Whiteboard

A preliminary investigation

PAULA MILDENHALL, **PAUL SWAN**, **MARIA NORTHCOTE** and **LINDA MARSHALL** outline how virtual manipulatives and interactive whiteboards can be used in the classroom.

Virtual manipulatives: What are they?

As part of the project titled "Hands-On Heads-On: The Effective Use of Manipulatives Both Virtual and Physical" being undertaken at Edith Cowan University, there was an investigation into the use of virtual manipulatives and the interactive whiteboard (IWB). Virtual manipulatives may be defined as a virtual representation of a physical manipulative which, through various dynamic processes may help develop mathematical conceptual understanding.

In order to find out how teachers have begun using the IWB, a teacher user group was created. As the group is in its early stages it is not possible to report detailed findings and these will be followed up at a later stage. However, where appropriate certain initial insights from this group have been included.

Providing students access to virtual manipulatives

The use of virtual manipulatives in mathematics education is fairly recent (Suh, Moyer & Heo, 2005) and there have been few studies of their effectiveness in learning (Steen, Brooks & Lyon, 2006). It is not surprising that virtual manipulatives have had little impact in primary education in Australia when computer use is not yet commonplace in K–3 classrooms (Dwyer, 2007). Some reasons for students not having easy access to information technology is the lack of professional development of teachers, the concerns that children may damage equipment, and the pressure to prepare students for standardised testing (Dwyer, 2007). In a survey by the New Zealand Council for Educational Research (2004), 52% of classes in early childhood settings (aged 3–5) did not use computers. The appropriateness of using computers with young children, and how and whether young children learn using technology such as computers and IWBs, should also be considered.

Globally there are examples of classroom teachers experimenting with the capabilities of using virtual manipulatives sites. For example, in the United States of America, Lambarty and Kolodner (2004) created a software system called *Digi quilt*, which allows "children to design patchwork quilt blocks in the context of learning about symmetry and fractions" (p. 143). Manipulatives are designed to promote thinking and help children grapple with abstract mathematical ideas (Moyer & Bolyard, 2002) and virtual manipulatives can play an identical role. Moyer and Bolyard recommend using virtual manipulatives to move the learner from the visual level of thinking to thinking through informal deduction and reasoning. For example, Moyer and Bolyard (2002) described how students can explore and build an understanding of the properties of quadrilaterals through the use of the site http://matti.usu.edu which presents, amongst other things, virtual pattern blocks. Figure 1 shows the quadrilaterals being dragged onto the page. One benefit here is that they are truly two-dimensional.

Cannon, Heal and Wellman (2000) were involved in the design and creation of the

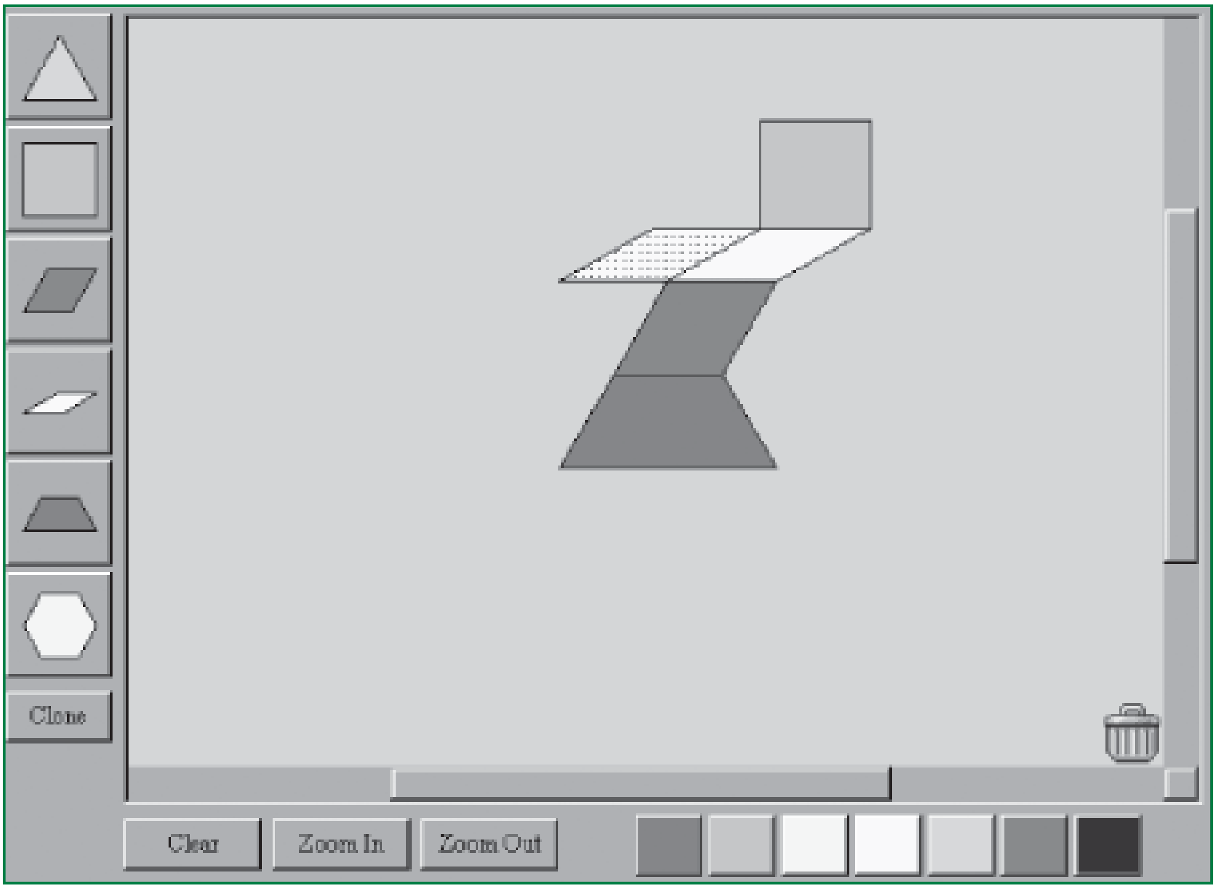

Figure 1. Virtual pattern blocks.

National Library of Virtual Manipulatives[1] (Utah State University, 1999). The library contains virtual versions of the existing concrete materials starting with an electronic version of the geoboard. The extract from the webpage in Figure 2 shows the geoboard being used with virtual elastic bands which can be dragged and put on to the pegs. Physical manipulatives have certain disadvantages; in the larger study it was noted that one of most common hindrances to the use of manipulative materials in mathematics was classroom management. Virtual manipulatives can overcome some of these issues.

Cannon et al. (2000) found that virtual manipulatives produced some benefits they had not imagined; for example, children could keep count by changing the colours of the faces of shapes. They listed the following advantages of virtual manipulatives:

- it is possible to record and store users' movements;
- they are freely available on the Web;
- parents and students can use these virtual manipulatives from their home computers;
- teachers who may be reluctant to send home concrete manipulatives for students' use may be more likely to give assignments to students who have access to virtual manipulatives through their home computers;
- there is potential for alteration (p. 1083).

Heddens and Speer (1995) identified similar advantages, adding that virtual manipulatives also make manipulatives accessible to diverse groups in the classroom such as students with special needs. Virtual manipulatives appeal to older students as being more sophisticated than using manipulatives in their concrete form (Moyer, Boyard & Spikell, 2002, p. 4).

1. See also Hot Ideas in this issue.

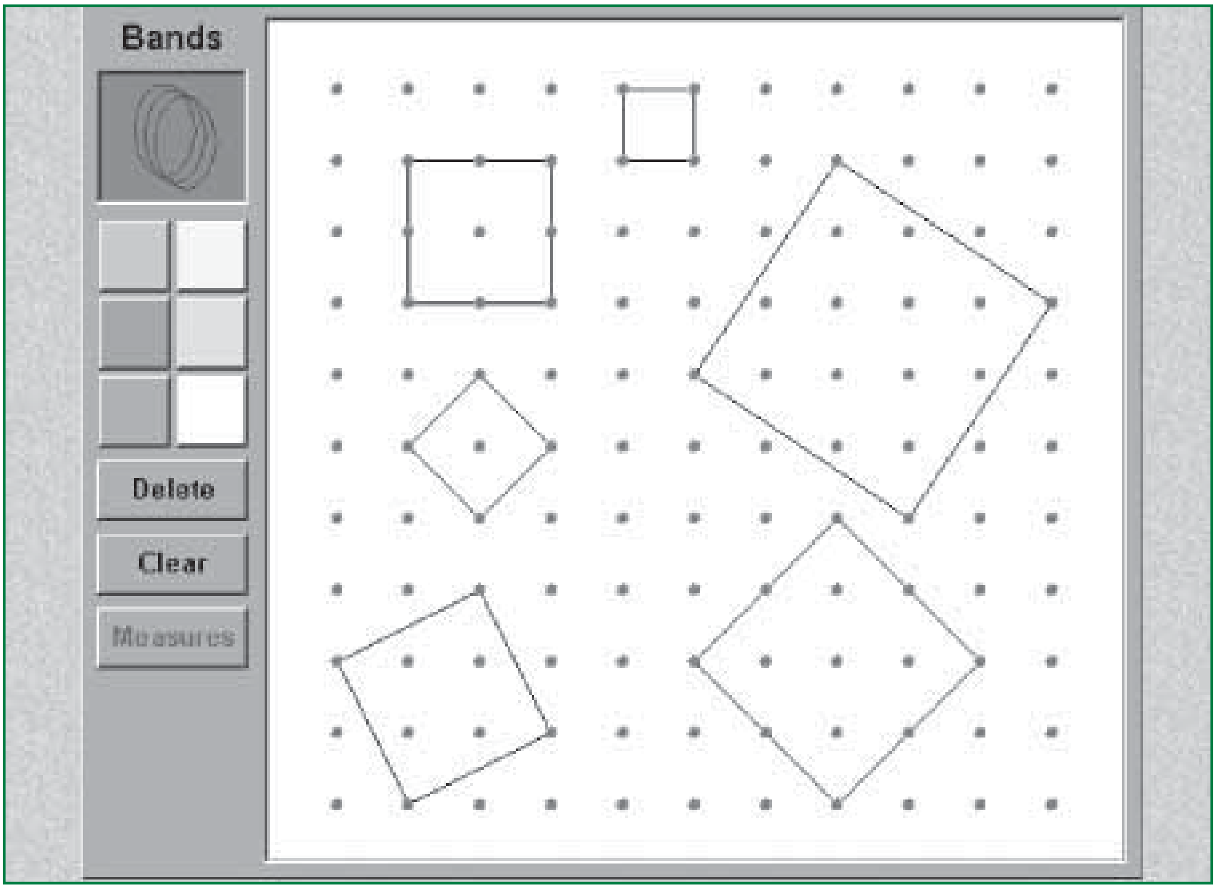

Figure 2. The virtual geoboard.

The interactive whiteboard as a platform for virtual manipulatives

With the introduction of virtual manipulatives and other computer software, it is a logical step to want to find a tool to show this information to the whole class. In order to avoid the IWB being used as a demonstration whiteboard, consideration needs to be given to how whole class, small group, pair and individual work are interrelated. Thompson (1992) adapted a projector screen connected to a Macintosh computer to achieve this result. Subsequently, the invention of the IWB has provided a purpose-built tool for this group interaction without needing any adaptation. In 2004, £25 000 000 was invested in IWBs in the United Kingdom (Beauchamp, 2004). However, the uses of IWBs extend beyond purely representing what is on a computer screen. Bell (2002, p. 2) makes the important point that, "since the boards can be used with any software, they are extremely adaptable for numerous uses and do not require acquisition of additional software."

Many of the initial research projects with IWBs have reported positive findings (Miller, Glover & Averis, 2004). For example, some teachers claimed that their teaching is more effective (Latham, 2002) and that students are more engaged (Beeland, n.d.). Bell (2002, p. 2) asserted that "the interactive whiteboard is an excellent tool for the constructivist educator." Miller, Glover and Averis (2005, p. 108) claimed that learning is encouraged by intrinsic simulation provided by the combination of the visual, kinaesthetic and auditory paths to learning. They also found the "sustained focus maintained throughout the lesson by the teacher's management and orchestration skills and stepped learning through constant challenges with frequent assessment of achievement as a stimulant to further involvement."

Our researchers have noted similar high interest when visiting schools making use of IWBs. Teachers in one school reported that the focus of the children increased dramatically as a result of the use of IWBs. It should be noted that the IWBs had been in place for three years and the "novelty effect" had worn off.

As its name implies, the IWB has the potential to support interactive learning (Latham, 2002; Miller et al., 2005). One strategy to achieve this is "to maximise the number of children working at the board so that they could develop their own self-esteem in use, and to stimulate the rest of the class to take part in what was happening at the board" (Miller et al., 2005, p. 107). Other strategies employed to achieve interactivity were:

> Exploiting opportunities for manipulation by teacher and pupil during lessons; the extended use of immediate feedback from software; using strategies for shared evaluations; the opportunity for differentiation of materials on the IAW [inter-active white-board] and using the IAW as a focus and catalyst in lessons. (Miller et al., 2005, p. 108)

This three-way interaction of teacher, pupil and learning material appears central to the IWB's potential contribution. A teacher creating this kind of interactivity was observed during our research. The Year 7 class was organised so that there were four groups with four or five children in each group. In turn they had to answer mathematical questions placed behind windows on the IWB. If they did not successfully answer the questions the rest of the class could have a chance at answering them. The teacher sat at the back with her laptop, and so the focus of the pupils was on the IWB. The teacher's role was to create the environment to allow this type of interaction and guide the discussion to explore students' responses.

Miller et al. (2005) found that as teachers became more experienced users of the technology they appeared to become more aware of the nature of interactivity that it facilitated. Consistent with this, the teachers in our user group often initially used the IWB simply for demonstration purposes but as they became

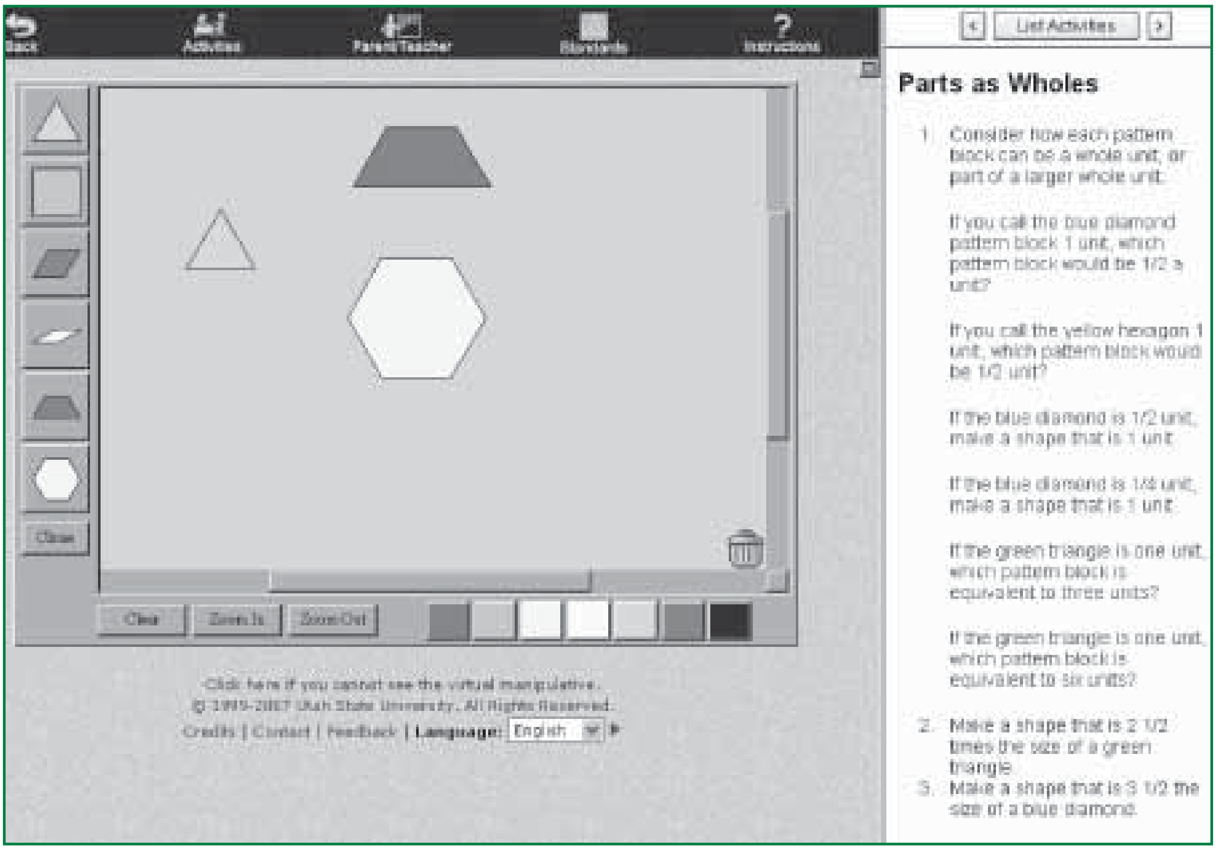

Figure 3. Virtual pattern blocks used to develop fraction concepts. [Note: in this screenshot the word “diamond” is used; the mathematically correct term is “rhombus.”]

more experienced they made the shift — the technology moving from a demonstration whiteboard to an IWB.

Using the interactive whiteboard to present virtual manipulatives

Due to its large size (similar to a standard whiteboard), the IWB allows virtual manipulatives to be viewed by the whole class rather than crowding around one small computer monitor. Primary mathematics teachers can use this technology where they see benefit in the whole class being involved. This means that the board can support, in an extremely effective manner, all of the other manipulative teaching that is taking place in the classroom.

The key component for the IWB to be effective is for it to be a tool that is utilised such that the classroom operates as a community of learners. Teachers need to consider their pedagogy, ensuring that their students are benefiting from the shared experiences. One effective use of the IWB in the classroom may be to tune students in and challenge students with activities such as that shown in Figure 3. This is a page taken from the National Library of Virtual Manipulatives, which can be used to teach fractions. This can be accessed via the IWB for a whole class to share or at the end of the lesson to share children’s strategies for solving the problems.

Concluding remarks

One of the limitations associated with the research conducted so far is that many of the findings concerning the IWB have been from small scale studies (Smith, Higgins, Wall & Miller, 2005). Despite this concern it seems reasonable to assert that IWBs have the potential to make manipulatives more accessible to large groups of children, and to use the shared learning experience within the classroom to further enrich students' learning.

It is perhaps pertinent to conclude this article with Cotton's (2006) comment that "a resource cannot force learners to describe what they are thinking, only good teaching can do this" (2006, p. 3). Many teachers may not be using virtual manipulatives because they do not have "an understanding of how to use representations for mathematics instruction as well as an understanding of how to use the technology" (Reimer & Moyer, 2005, p. 2). The type of classroom in which computers are placed is clearly the crucial factor, and in this way virtual manipulatives are no different from physical manipulatives. If teachers become clearer about how they can make sure their classroom are places of active engagement, virtual manipulatives and the IWB may be a worthwhile addition.

References

Beauchamp, G. (2004). Teacher use of the interactive whiteboard in primary schools: Towards an effective transition framework. *Technology, Pedagogy and Education, 13*(3), 327–346.

Beeland, M. (2002). Student engagement, visual learning and technology: Can interactive whiteboards help? Retrieved 12 February, 2007, from http://chiron.valdosta.edu/are/Artmanscrpt/vol1no1/beeland_am.pdf

Bell, M. (2002). Why use an interactive whiteboard? A baker's dozen reasons. Retrieved 14 March 2007 from http://teachers.net/gazette/JAN02/mabell.html

Cannon, L., Heal, R. & Wellman, R. (2000). Serendipity in interactive mathematics: Virtual (electronic) manipulatives for learning elementary mathematics. In C. Crawford et al. (Eds), *Proceedings of the Society for Information Technology and Teachers Education International Conference 2000* (pp. 1083–1088). Retrieved 20 February 2008 from http://www.editlib.org/index.cfm?fuseaction=Reader.ViewAbstract&paper_id=15782

Cotton, T. (2006). Mummy how heavy are mushrooms? *Mathematics Teaching, 194*, 37–40.

Dwyer, J. (2007) Computer-based learning in a primary school: Differences between the early and later years of primary schooling. *Asia-Pacific Journal of Teacher Education, 35*(1), 89–103.

Heddons, J. & Speer, W. (1995). *Today's Mathematics*. Englewood Cliffs: Merrill.

Latham, P. (2002). *Teaching and Learning Primary Mathematics: The Impact of Interactive Whiteboards*. London: Beam Education.

Lamberty K. & Kolodner, J. (2004). Toward a new kind of computational manipulatives: Children learning math and designing quilts with manipulatives. *Proceedings of the 2004 conference on Interaction Design and Children: Building a Community* (pp. 143–144). New York: ACM Press.

Miller, D., Glover, D. & Averis, D. (2004). *Developing the Pedagogic Skills for the Use of the Interactive White Board in Mathematics*. Retrieved March 2007 from http://scholar.google.com/scholar?hl=en&lr=&q=cache:EEjfqwvU_MUJ:www.keele.ac.uk/depts/ed/iaw/docs

Miller, D. Glover, D. & Averis, D. (2005). Presentation and pedagogy: The effective use of interactive whiteboards in mathematics lessons. In D. Hewitt and A. Noyes (Eds), *Proceedings of the 6th British Congress of Mathematics Education, 25* (1), pp. 105–112. London: British Society for Research into Learning Mathematics.

Moyer, P. & Bolyard, J. (2002). Exploring representation in the middle grades: Investigations in geometry with virtual manipulatives. *The Australian Mathematics Teacher, 58*(1), 19–25.

Moyer, S., Bolyard, J. & Spikell, M. (2002). What are virtual manipulatives? *Teaching Children Mathematics, 8*(6), 372–377.

NZCER. (2004). *The Role and Potential of ICT in Early Childhood Education: A Review of New Zealand and International Literature*. Retrieved 22 October 2007 from http://www.minedu.govt.nz/index.cfm.l

Reimer, K. & Moyer, P. (2005). Third-graders learn about fractions using virtual manipulatives. *The Journal of Computers in Mathematics and Science Teaching, 24*(1), 5–25.

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

Steen, K., Brooks, D. & Lyon, T. (2006). The impact of virtual manipulatives on first grade geometry instruction and learning. *Journal of Computers in Mathematics and Science Teaching, 25*(4), 373–391.

Suh, J., Moyer, P. & Heo, H. (2005). Examining technology uses in the classroom: Developing fraction sense using virtual manipulatives concept tutorials. *Journal of Interactive Online Learning 3*(4), 1–21.

Thompson, P. (1992). Notations, conventions, and constraints: Contributions to effective uses of concrete materials in elementary mathematics. *Journal for Research in Mathematics Education, 23*(2), 123–147.

Utah State University. (1999). *National Library of Virtual Manipulatives*. Retrieved 27 September 2007 from http://nlvm.usu.edu/en/nav/category_g_3_t_3.html

Paula Mildenhall, Edith Cowan University, WA
<p.mildenhall@ecu.edu.au>
Paul Swan, Edith Cowan University, WA
Maria Northcote, Edith Cowan University, WA
Linda Marshall, Edith Cowan University, WA

APMC