USING AN INTERACTIVE WHITEBOARD TO FACILITATE PUPIL UNDERSTANDING OF QUADRILATERAL DEFINITIONS

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This paper reports on part of a project[1] examining how the affordances of interactive whiteboards can facilitate conceptual learning. Here the focus is on the teaching of quadrilateral definitions through the use of Cabri Géomètre. It appears that Year 5 pupils can gain a good grasp of the inclusive nature of quadrilateral definitions with suitable teaching that employs Cabri and the interactive whiteboard.

INTRODUCTION

This paper reviews preliminary work, some of which has been previously reported in Pratt & Davison (submitted). The purpose of this research was to look for examples of the affordances of the interactive whiteboard (IW) aiding conceptual learning in the classroom. From our[2] previous unpublished interviews with teachers, there is little evidence of this taking place in 'normal' lessons, so we designed our own lessons.

We needed to focus upon a topic which was both visual and conceptually demanding. To us, geometry met these criteria and it is also an important part of the National Curriculum. In addition, there is a sizeable literature which concerns the teaching of mathematics using dynamic geometry software (DGS). For example the Royal Society and JMC (Royal Society, 2001) specifically advocated the teaching of geometry using DGS on an IW. We aspire to relate the affordances of the IW not only to the use of DGS but also to the teaching process itself with particular emphasis on the tasks and the teacher/class discourse.

Fischbein (1994) analysed geometrical reasoning in terms of 'figural concepts'. Such concepts fuse visualisations (figures) with conceptual attributes. The conceptual aspect should control the figural; but children typically allow the visual component a controlling role. Thus, a student who knows the definition of a parallelogram may nevertheless find difficulty in recognising the various shapes that correspond to that definition. An oblique parallelogram, a square and a rectangle are so figurally different that the unifying effect of the common concept simply vanishes. It is plausible that the IW could support the enhancement of children's figural concepts for quadrilaterals by supporting the figural component through the visual impact of the IW whilst encouraging the conceptual component through the kinaesthetic affordance.

PILOT LESSONS

These seven lessons took place in the Autumn term of 2002, and involved a Year 7 class. The intention was to give the pupils some familiarity of Cabri, to teach or reinforce properties of triangles, quadrilaterals, and other polygons. Also, there was a lesson investigating reflections and another exploring loci. Three pairs of pupils were interviewed before and after the lessons, and during the lessons their speech and on-screen actions were recorded directly to 'video'[3]. The IW work was also recorded.

Findings from the Pilot Lessons

Due to shortage of space, we focus our report on the work and thinking of 2 girls, whom we shall call Christine and Michelle. Lesson 3 was devoted to construction of quadrilaterals; and the idea that a square is a special type of rhombus was raised in the final plenary on the IW. Then in lesson 4, the children attempted to construct quadrilaterals from their diagonals. Christine and Michelle constructed a square with some help from the teacher. After one or two false starts and a little more help, they also constructed a kite. One of the girls then dragged the kite into a rhombus, and the researcher prompted the girls to agree that the rhombus was a special type of kite.

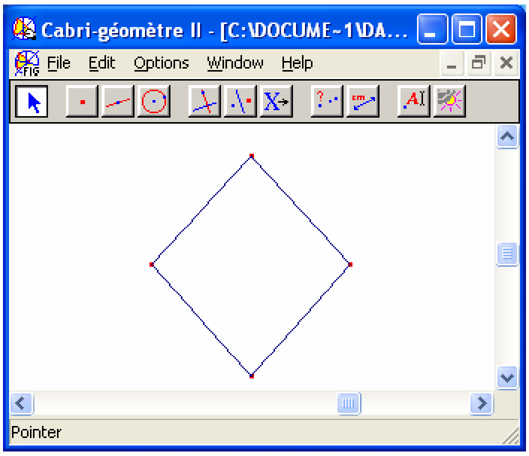

Figure 1: The initial "rhombus" kite

During the subsequent interview, we presented Christine and Michelle with the construction in Figure 1, which could appear as a rhombus, square or kite. Before the girls attempted to drag the figure, Michelle described it as "It's like a rhombus, but turned"; and Christine explained why it wasn't a kite: "Aren't kites meant to be longer at the bottom than at the top?" Therefore, both girls are at this stage were attending to the visual aspects. Next, they rotated the figure into a position that was close to a prototypical rhombus; this made them much more confident that it was a rhombus.

Then they altered the figure so it was clearly no longer a rhombus. They recognized the kite but were confused because the first point they dragged confirmed that the shape had been constructed to be a rhombus, but the next point seemed to mess it up.

1	C:	Hey! [laugh] I don't get that.
2	M:	That was a kite, look that goes along there… I don't get how it can be constructed and drawn?
3	I:	Ahh! Just say what you mean there?
4	M:	Well, those 2 points change…{yeah} and they're constructed… And the other corner…{yeah} those 2 just...don't work [embarrassed laugh]… They like aren't constructed…they can mess it up…
5	C:	Yeah, they can mess it up
6	M:	It's not a messed up kite, but it is a messed up rhombus. {Yeah}
7	C:	No it's not, because it's a square that's changed, which is…

Michelle at least had recognized that the notion of messing up needed to be related to the figure supposedly constructed (line 4). They could regard the figure as the construction of a kite but not of a rhombus, but this understanding was far from stable.

8	I:	So can you mess the kite up?
9	C:	That doesn't look like a kite any more. But if you look like that…
10	M:	That one looks longer than that one. But sometimes it looks like a kite, and sometimes it doesn't.

The girls were still struggling with the idea that the kite sometimes looked like a rhombus. A resolution to this paradox would have been to incorporate rhombuses into their definition of kites i.e. to see rhombuses as special types of kites. It seemed though that their definitions were close to the prototypical visually based component of the figural concept. The pedagogical challenge here was clearly to find a means of helping the girls to focus on defining the figure in terms of its properties. The dragging movement was raising the conflict but the resolution was not apparent to them.

MAIN LESSONS

These lessons followed the same pattern as the pilot. However there were some significant changes. The lessons were with Year 5 pupils, and the researcher took a lead role in teaching. The five lessons were specifically focussed upon the inclusive nature of quadrilateral definitions. In brief the lessons were:

1) Familiarity with Cabri commands. Difference between construct and draw.
2) Consolidation of lesson 1 ideas, plus investigating triangles.
3) Construction of quadrilaterals.
4) Dragging quadrilaterals into other quadrilaterals, and relating this to their properties.
5) Deciding on the 'best' rectangle, and using this to construct a definition.

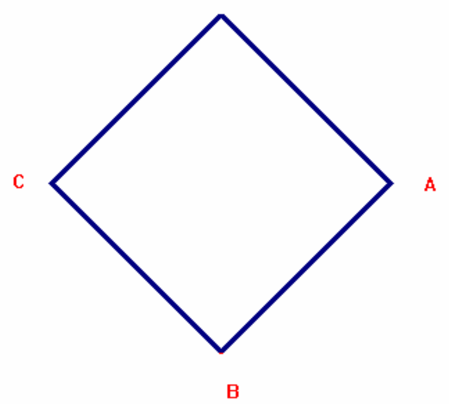

Figure 2: Initial 'square' rhombus

We report on two Year 5 girls who worked together and who will be referred to as Nina and Vanessa. There were numerous instances in the lessons in which the teacher emphasised various aspects of the inclusive nature of quadrilateral definitions. In the final lesson, pupils were asked to experiment with the 4 rectangles that were constructed in different ways. It is interesting that only one of the class chose the 'correct' rectangle, and the rest of the class chose rectangles which could not be dragged into a square. Therefore it is likely that almost all the pupils were still attending primarily to the figural aspects of the definitions (Fischbein, 1993). So, in line with Mariotti's (1994) contention that the tension between figural and conceptual aspects must be made explicit, the teacher/ researcher was able to address this issue using the IW.

Consequently, it was interesting to discover how much the two girls had understood. So, in the subsequent interview, the girls were shown Figure 2 in Cabri. First they were asked to describe the shape. Next they dragged the corners A, B and then C in turn. This rhombus looked like a square to begin with. When corners A and B were dragged, the size and orientation altered, but it remained a square, so that the girls said that the shape was constructed as a square. However, dragging corner C altered the angles making it clear (to mathematicians!) that the shape was constructed as a rhombus. This task was designed to create surprise, and this certainly worked with these girls. The idea then was to see if they could explain how a shape that had appeared to be constructed as a square could suddenly turn into a non-square rhombus.

I Why were you surprised?

N It wasn't a rhombus before

V because…because…from C it was constructed as a rhombus, and from A it was constructed as a square.

So clearly the girls were aware of the problem and initially they were unsure how to resolve it. After a little discussion, the interviewer asked them if it was constructed as a square or a rhombus:

N A rhombus.

V Yeah, because look, if you construct it as a rhombus at C, it stays a rhombus (she was dragging point A, making the rhombus change in size and orientation, but maintaining the same shape).

It appears that Vanessa was using the drag mode to work through this problem; and quite soon afterwards they found the solution.

V If it was a rhombus, it would be able to construct into a square because it has the same properties; but you couldn't turn a square into a rhombus because a square… I don't know.

N A constructed square cannot change into a rhombus, because it's constructed as a square.

I So what it is that means it can't be a rhombus?

V 'Cos a square has 4 angles that are all 90 degrees. A rhombus doesn't have any really special angles, so it could become a square and still be a rhombus.

Next, the researcher checked the stability of the girls' understanding by showing them a rectangle and dragging it into a parallelogram, and asking how it was constructed:

N I don't know.

V Parallelogram, because that's not a rectangle (pointing to the shape) [I: right] but these are still like parallel (as she drags the parallelogram into a rectangle). In a rectangle…

N I agree… a rectangle, just like the square, has 4 corners of 90 degrees, and that's a property of the rectangle [I: yes, good] and so a parallelogram does not have any really special angles, so I think it's constructed as a parallelogram.

Interestingly, Vanessa again used a kinaesthetic approach. It appears that the technology is mediating her thinking (Noss and Hoyles, 1996). It is also interesting that Nina quickly grasped the idea as Vanessa was talking and demonstrating.

Findings from the Main Lessons

The inclusive nature of quadrilateral definitions is complex for pupils to grasp. This is because they need sound understanding of the properties of the shapes and good comprehension that the properties of some shapes are subsumed into others (e.g. a square has all the properties of a rhombus, and an extra property as well). After the 5 lessons and the interview, these two Year 5 girls showed impressive understanding.

It appears that several factors were required to aid these pupils in the development of this understanding. First, the pupils had several opportunities to see that some quadrilaterals are special examples of other quadrilaterals. This was aided by dragging the quadrilaterals on their PC and on the IW. Secondly, the 'Rectangles' lesson gave them the chance to become 'definers' and then to have their definition challenged by the teacher (see De Villiers, 1998). It is felt that is may have had a profound effect on their thinking. Finally, it was clear that the girls in our study also constructed meaning during the final interview. This construction process appears to have been aided by the opportunity to drag the shapes and to discuss between themselves. In Fischbein's (1993) terminology, the girls have made good progress towards fusing the visual and conceptual facets of quadrilateral definitions into figural concepts.

CONCLUSION

Our intention was to look for evidence that the kinaesthetic affordances of an IW could promote conceptual learning. We focussed upon the learning of the inclusive nature of quadrilateral definitions because it is both highly visual and conceptually demanding.

The pilot lessons gave pupils experience of dragging quadrilaterals into other quadrilaterals on their PC, and seeing it happen on the IW. There appeared to be good kinaesthetic use of the IW, but pupil understanding was disappointing when subsequently tested during interviews.

The main lessons were more tightly focussed on quadrilateral definitions, so that the pupils had more relevant experiences both on their PC and with the IW. In addition, pupils were asked to be definers, and the reasons for inclusive definitions was discussed explicitly. Also, the researcher acted as the principal teacher. These changes seemed to produce a favourable outcome in that the interviewed pupils displayed a stronger appreciation of quadrilateral definitions and they were able, with prompting, to explain their inclusive nature. This is despite the participation of younger pupils.

However, with so many alterations, the importance of each element is unclear. In addition, there was a considerable time input from the researcher in preparing each lesson. Furthermore, the final interview seemed to be a powerful learning episode. Clearly we would wish to see unaided teachers successfully implement this scheme.

It should be noted that we have focussed purely upon a small area of the mathematical curriculum. Of course, further research would be needed to see if our findings are applicable to other curricular areas, age groups and schools.

Although tentative at this stage, our conjecture is that the kinaesthetic affordances of the interactive whiteboard were being used effectively in the main study. But also, and perhaps more importantly, the IW was an effective forum for discussion.

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[1] I wish to thank BECTA and Research Machines PLC for providing funding for this project

[2] This and the previous work was done in collaboration with Dr Dave Pratt, also at Warwick University

[3] The computers ran Camtasia software in the background to record these screen and speech acts. This software is produced by TechSmith Corporation, http://www.techsmith.com/products/camtasia/camtasia.asp