Imag(in)ing three-dimensional movement with gesture: 'playing turtle' or pointing?

Candia Morgan and Jehad Alshwaikh

Institute of Education/London Knowledge Lab, London

Abstract: Use of the metaphor of 'playing turtle' is commonly seen as an important and successful way in which students may make sense of construction of two-dimensional shapes in Logo turtle geometry. During teaching with a three-dimensional 'turtle world', teachers and researchers made extensive use of specialised hand gestures when attempting to communicate with students about three-dimensional movement. While students made use of similar gestures, we found that the meanings they appeared to make with the gestures were different from those anticipated and that the 'playing turtle' metaphor did not easily transfer into the three-dimensional context. We will discuss how use of gestures in this context related to other modes of representation available to the students.

Keywords: gesture; Logo; representation; three-dimensional geometry

Introduction

It may be argued that three-dimensional geometry is all around us in the space we inhabit. Yet common approaches within the school curriculum provide relatively limited forms of experience, often relying almost exclusively on paper-based two-dimensional representations of three-dimensional objects. Operating with such representations of three-dimensional space requires a focus on the properties and relationships within and between objects and familiarity with the conventions of specialised semiotic systems (e.g., perspective drawing, isometric drawing, plans and elevations). We conjecture that some of students' difficulties with three-dimensional geometry arise from a disjunction between their everyday physical experience of space and their experiences with such conventional systems.

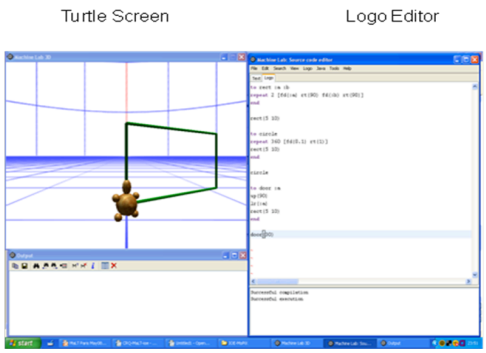

Figure 1: MaLT screenshot

In this paper we report on a teaching experiment, involving a multi-semiotic interactive learning environment, MachineLab Turtleworld (MaLT), produced as part of the ReMath project [1]. This environment, designed by the University of Athens Educational Technology Lab (ETL) project partners, incorporates a three-dimensional turtle geometry, driven by a Logo-like language (see Figure 1). It also includes variation tools for direct manipulation of variables, though we do not discuss this component of the software in this paper. The

[1] ReMath (Representing Mathematics with Digital Technologies) funded by the European Commission FP6, project no. IST4-26751.

pedagogical plan used in the London-based teaching experiment [2] was designed to allow us to investigate the meanings students would make in relation to three-dimensional Logo geometry through their semiotic activity in the context of working with MaLT and other modes. The teaching experiment was conducted with a Year 8 class (aged 12-13 years) in a state secondary school in London. The school set students by attainment for mathematics; this class was ranked 4 out of 5 in the year group. A sequence of nine lessons was taught collaboratively by the class teacher, the researchers and a student teacher attached to the class.

A multimodal, multi-semiotic learning environment

Interacting with MaLT itself involves making use of several inter-related systems of representation, including: the paths formed by turtle movement in the Turtle Screen (graphic), instructions and procedures constructed in the Logo Editor (symbolic) and the variation tools (dynamic visual and symbolic). The social environment of the teaching experiment was intended to allow, and indeed encourage, communication through talk and various paper-and-pencil based forms of representation. Moreover, wherever mathematical communication takes place in face-to-face contexts, body language and gesture also play a part (see, for example, Bjuland, Cestari, & Borgersen, 2007; Radford & Bardini, 2007). Each of the various available semiotic systems provides a different range of meaning potentials (Kress & van Leeuwen, 2001). For example, as O'Halloran argues, visual modes such as graphs allow representation of 'graduations of different phenomena' rather than the limited categorical distinctions available through language or algebraic symbolism, while dynamic modes additionally allow the representation of temporal and spatial variation (2005, p.132). In investigating the meanings that students make within such a multi-semiotic environment, it is important to consider their use of all these modes and the relationships between them. See Morgan & Alshwaikh (2009) for more details of the transcription and analytic methods used with such multimodal data.

Why consider gesture?

As we started to view the video data collected during use of MaLT, it was noticeable that the teachers and researchers made extensive use of gestures in an apparent attempt to support students' planning and execution of constructions in MaLT. One significant type of gesture was a set of stereotyped hand and/or arm movements, often associated with use of the terms *turn*, *pitch* (or more frequently *up* or *down*) and *roll* and the associated Logo instructions (see Figure 2 for the codes used in transcription of these gestures). This set of gestures constitutes a new semiotic system, linked with, but not identical to, both the linguistic description of three-dimensional movement and the symbolic system of Logo. Students also made use of these and other gestures to support their communication about turtle movement. We became interested in students' adoption of these new signs and in the

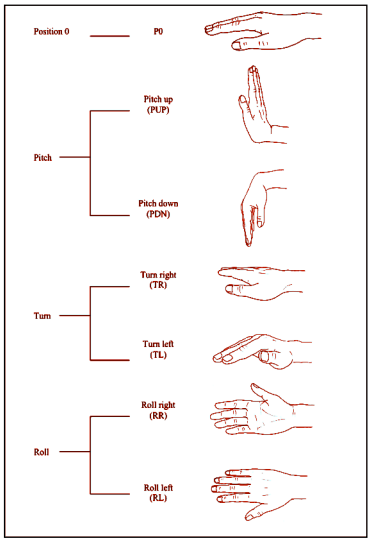

Figure 2: MaLT gesture codes

[2] The pedagogic plans used in the ReMath project may be found at http://remath.itd.cnr.it/index.php

relationships between the semiotic activity of teachers and researchers and that of the students.

Playing turtle

For the teachers and researchers, using these gestures as ways of thinking and communicating about movement of the turtle within MaLT seems a natural consequence of our experience with using two-dimensional versions of Logo. The metaphor of 'playing turtle' formed part of our experience of 'Logo culture' and constituted for us a more or less implicit theory about learning with Logo. In Papert's seminal Mindstorms (1980), he argued that turtle geometry is useful for learning because it is *body syntonic*, "firmly connected to children's sense and knowledge about their own bodies" (p.63). This connection to personal bodily knowledge is operationalised through 'playing turtle', either literally by walking along a path or metaphorically in the imagination.

In the 3D context, it is not possible to physically act out turtle movements with the whole body. Instead, the hand (or a toy aeroplane held in the hand) substitutes for the body. Our Greek partners ETL incorporated the idea of body syntonicity as an explicit theoretical justification for their own pedagogical plan, implemented in Athens:

> This is a sequence of tasks for students, taking them from an initial introduction to the software and its functionalities through to a number of geometrical simulation challenges in the 3d space and opportunities for creative exploration through body syntonic activities. Initially students will be asked to explore turtle's turns and moves by using different sets of 3d Logo commands and then to use them to demonstrate an aeroplane taking-off with the use of a relevant tangible concrete object (e.g. a model of a 3d aeroplane).

We adopted a similar initial activity in our own introduction of MaLT to London students, and, having done so, also incorporated use of gesture into our further communications about three-dimensional movement throughout the teaching experiment, attempting to encourage students to associate a sense of their bodily movement with the Logo symbolism.

We now briefly present two episodes from the teaching experiment in which the teachers and researchers modelled use of gestures to 'play turtle'. Then we present in somewhat more detail an analysis of an episode of a student's use of similar gestures. In the next section, we discuss differences in the meanings associated with the gestures by teachers and researchers and by the student.

Episode 1:

In the introductory session with MaLT, the first author introduced the notion of turtle movement using a toy aeroplane as described in the ETL team's pedagogical plan. She accompanied the physical movement of the hand/aeroplane with a verbal description, using and stressing the terms *pitch*, *roll* and *turn* in synchrony with the associated gestures.

Episode 2:

In a later lesson, recognising that some students were still having difficulty distinguishing between these different kinds of turn, the class teacher used her arm and hand to act out the role of the turtle drawing a 'door' under instruction from the

class. She was careful to follow the conventions of the gesture system in order to emphasise the relative nature of turtle movement. Thus, for example, she turned her hand in a *down pitch* gesture when given the instruction to go down, even though this resulted in her hand pointing horizontally as in Figure 3. This resulted in conflict for students between their intended outcome and the visual feedback provided. This conflict was quickly resolved with choice of the correct Logo turn instruction.

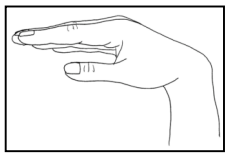
Figure 3: down pitch

Episode 3:

T, having constructed one rectangular wall, was trying to construct a second wall perpendicular to the first. She explained what she was trying to draw using language and gesture. Her words are shown in Table 1, together with a verbal description and a sketch of the accompanying gesture.

Table 1: T imagines a wall

1	here	*whole rt arm vertical P0, palm facing away from body, moves up in direction of fingers*	
2	turn here	*TR, arm moved in direction of fingers (maintaining TR position)*	
3	turn here	*attempt to move rt hand TR again (too difficult?)*	
4		*switch to lt hand, arm horizontal pointing rt, hand PDN (fingers pointing down)*	
5	turn here	*moves forearm clockwise, hand still PDN (fingers pointing left)*	
6	but I want it to come forward	*turns arm (awkwardly) so that, hand still in PDN position, fingers point towards body*	

The switch (lines 3 - 4) between use of right and left hands appears to be a response to the physical difficulty of achieving the desired position with the right hand (see Figure 4).

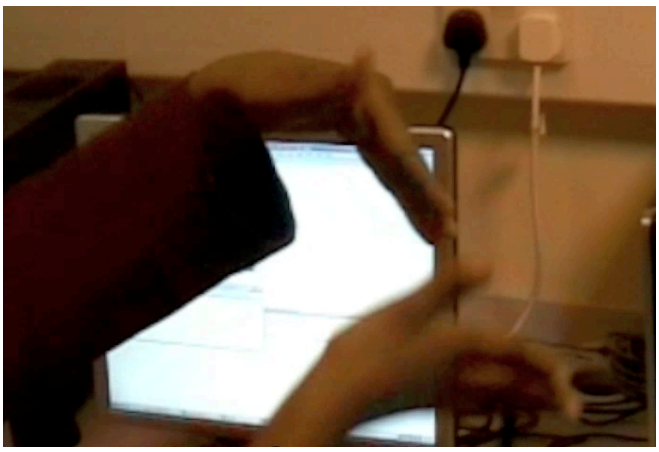
Figure 4: T switches hands

We consider what remains the same and what is changed with this switch of hand. The switch allows T to maintain the direction in which the fingers are pointing (down). This may be taken to represent the turtle heading within the vertical plane parallel to the screen. However, in switching arms, she changes the relationship between arm and hand from a *turn* gesture to a *pitch* gesture. We use *turn* and

pitch within the conventions set up by the teachers/researchers and the Logo language, not to suggest that T associates her gestures with these terms. On the contrary, she does not appear to attach any significance to the distinction, focusing solely on the position of her hand and the direction in which her fingers are pointing in order to describe the intended turtle movement. While she is to some extent 'playing turtle' with her hand, she is defining the turtle's movements by using position and heading at the corners of her imaginary wall rather than by using turn and distance as required by the Logo language. The use of the turn and pitch gestures is thus not supporting her move into using Logo code and may indeed have made her communication with teachers/researchers less effective.

Contrasting gestures: imaging process vs. imagining object

In considering the difference between the ways in which teachers/researchers and students were using the 'same' gestures, we distinguish between the two notions of *imaging* and *imagining*. We define *imaging* as using gesture to create an image of the construction of the turtle path. The movement of the hand mimics the movement of the turtle: the forearm is held parallel to the current heading of the turtle and the hand is moved to define the next heading. Thus, as in Figure 5, the gesture indicating 'up pitch' is always relative to the current heading of the turtle. In both episodes 1 and 2, the teacher/researcher gestures were imaging the process of construction of the turtle path.

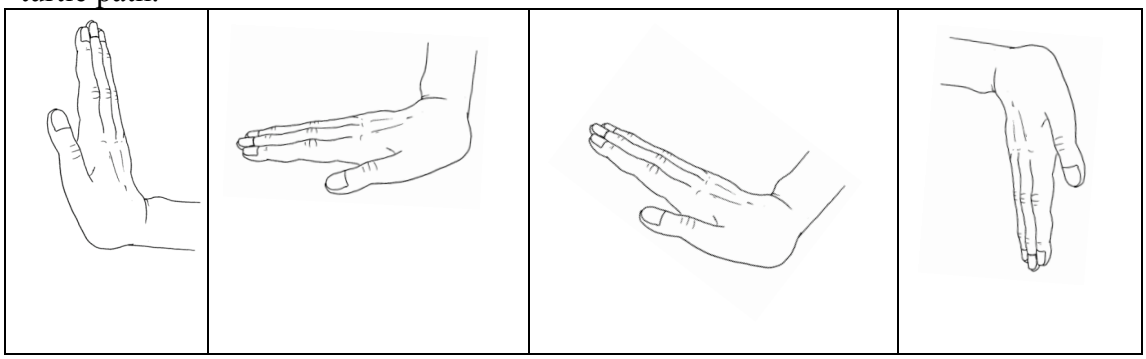

Figure 5: All these gestures indicate 'up pitch'

In contrast, in episode 3 student T used apparently similar hand movements to construct very different meanings. For her, the relationship between forearm and hand did not appear to have significance, as she was willing to substitute a pitch down gesture with her left hand for a turn right gesture with her right hand. We characterise her use of gesture as *imagining*, referring to her mental image of the desired outcome of turtle drawing. In this episode, as in several other episodes of student gesture within the data set, the gesture indicates the desired direction of movement in order to draw the desired outcome, rather than indicating the required type of turn. Thus, for example, a movement in the 'up' direction (within the plane of the screen) might be indicated by use of the spoken word "up" and a 'down pitch' gesture (Figure 6).

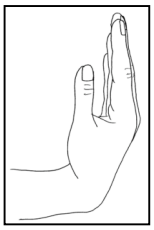

Figure 6: 'down pitch' indicates 'go up'

Concluding remarks

Teachers and researchers used specialised hand gestures to communicate with students about three-dimensional movement. Students used the 'same' gestures but to communicate different meanings in relation to turtle movement. Whereas the *imaging*

by teachers/researchers mimicked turtle movement in a kind of 'playing turtle' action, student use of gesture to *imagine* the outcome of the movement seems closer to deixis, pointing in the direction of movement from a viewpoint outside the turtle. Indeed, one student explicitly refused to accept the 'playing turtle' metaphor offered to her by a researcher:

JA if you imagine yourself as a turtle, how are you going to move?

K it is very uncomfortable imagining myself as a turtle ... erm

JA or imagine your hand

K I don't want to be a turtle

Pointing is a widespread form of representation of position, common in everyday discourse. While it might appear at first sight that students adopted the specialised gestures employed by the teachers/researchers, the students' use and interpretation of these gestures may be closer to the resources of everyday discourse than to those of the MaLT microworld.

While the scope of the teaching experiment described here was limited, our observation of these different ways of gesturing turtle movement leads us to ask whether the 'playing turtle' metaphor is fully adaptable and relevant to the three dimensional context? While we have extensive knowledge of our own body movement in the normal two-dimensional horizontal plane that can be connected to the movement of a turtle in the vertical plane of the computer screen, our experience and knowledge of movement in three dimensions is much more limited. Many of the movements required of a turtle constructing a path in the three-dimensional space of MaLT are impossible for the human body within its normal environment. The extra leap of imagination required to 'play turtle' as if in control of an acrobatic aircraft or perhaps in deep water with highly developed underwater manoeuvrability may be too great for genuine body syntonicity.

References

Bjuland, R., Cestari, M. L., & Borgersen, H. E. (2007). Pupils' mathematical reasoning expressed through gesture and discourse: A case study from a sixth-grade lesson. In D. Pitta-Pantazi & G. Philippou (Eds.), *European Research in Mathematics Education V: Proceedings of the Fifth Congress of the European Society for Research in Mathematics Education* (pp. 1129-1139). Larnaca, Cyprus: Department of Education, University of Cyprus.

Kress, G., & van Leeuwen, T. (2001). *Multimodal Discourse: The modes and media of contemporary communication*. London: Arnold.

Morgan, C., & Alshwaikh, J. (2009). *Mathematical activity in a multi-semiotic environment*. Paper presented at the Sixth Congress of the European Society for Research in Mathematics Education, Working Group 6 Language and Mathematics.

O'Halloran, K. L. (2005). *Mathematical Discourse: Language, Symbolism and Visual images*. London: Continuum.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. New York, NY: Basic Books.

Radford, L., & Bardini, C. (2007). Perceiving the general: The multisemiotic dimension of students' algebraic activity. *Journal for Research in Mathematics Education, 38*(5), 507-530