•• What can we all say?" Dynamic geometry in a whole-class zone of proximal development.

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This paper first develops a theoretical background which culminates in a discussion of the promotion and fostering of socio-mathematical norms (Cobb and Yackel, 1996)*, the significance of local communities of practice (Winboume and Watson,* 1998) *and the development of a whole-class ZP D (H edegaard,* 1991, *Lerman,* 1998). *It then seeks to indicate a way in which classroom aproaches by teacher and pupils to a dynamic geometry package (Cabri* 2 *as available on the TI 92) might use this background*

Theoretical Background

Vygotsky(1962) proposed a social background to learning and formulated the Genetic Law of Cultural Development, proposing that learning moves from the social to the personal. He took up the idea of the Zone of Proximal Development as the area where interaction between the individual and the social leads to development. Lerman (1998) has pointed out that his original definition was in terms of intelligence testing and the idea of the ZPD has been developed by later workers. The broadening of the definition over time is perhaps an indication of the wide applicability of the concept. It has been used both as a precise analytical tool and as a useful broad band of ideas. Definitions of the ZPD have ranged from those related to development and 'scaffolding', (Vygotsky, 1962, Bruner, 1985 :25), to assessment (Vygotsky 1956 :446-448), to the distinction and interaction between spontaneous and scientific concepts, (Kozulin, 1986, Gardiner and Hudson 1998) to definitions in activity theory (Engestrom 1987, 174), and to the class and teacher as a whole Hedegaard (1990). Lave and Wenger (1991 :48-49) discuss this movement to a broader cultural definition of the ZPD.

Of particular interest here is a definition of the ZPD which includes the classroom as a whole, in this case incorporating the teacher, the pupils and the technology. Hedegaard has reported (1990) in terms of the development of a whole-class ZPD rather than the analysis of an individual's learning.
"This activity, in principle, is designed to develop a zone of proximal development for the class as a whole, where each child acquires personal knowledge through the activities shared between the teacher and the children and among the children themselves." (p 361). Hedegaard reports in the same paper a motivational shift in children's focus, from an interest in the concrete to interest in the derivation of

principles which can be applied to the concrete. Lerman (1998) takes the discussion further.

" The ZPD is the classroom's, not the child's. In another sense it is the researcher's: it is the tool for analysis of the learning interactions in the classroom (and elsewhere). "(p 71)

Lave and Wenger (1991) see learning as situated in society and introduce the concept of 'Legitimate Peripheral Participation'. They bring forward the idea of masters and apprentices(or newcomers) and emphasise that situated learning is often independent of teaching. In discussion of reports of five master/apprentice situations they say:

"In all five cases ....researchers insist that there is very little observable teaching; the more basic phenomenon is learning." (p 92)

Drawing on further work by Lave (1993), Winboume and Watson (1998) have used the idea of 'local communities of (mathematical) practice'. They provide a useful definition of such a community of practice and a summary of the features which are necessarily present in a classroom if those within it

'are to constitute a local community of practice:

1. Pupils see themselves as functioning mathematically within the lesson;
2. Within the lesson there is public recognition of competence;
3. Learners see themselves as working together towards the achievement of a common understanding;
4. There are shared ways of behaving, language, habits, values and tool-use;
5. The shape of the lesson is dependent upon the active participation of the students;
6. Learners and teachers see themselves as engaged in the same activity. '(p 183)

This approach is echoed in the work of Cobb and Yackel (1996), who have analysed mathematics classrooms in terms of the negotiation and maintenance of social and socio-mathematical norms. Social norms include insistence on explanation of answers, respecting the contribution of others and making clear agreement as well as disagreement. Socio-mathematical norms would include some notion of what constitutes a valid, complete solution, and agreement on the worth of alternative solutions. Negotiation must take place on how teacher and students agree on the mutual acceptability of solutions. Of course social norms will exist in all classrooms, and will bear a direct relationship to the society in which the classroom is situated. Because social norms will affect the negotiation of socio-mathematical norms, Apple (1992) has argued that the classroom must be frrmly situated in the wider context of the practices of school and society.

I wish to argue here that these approaches, of a whole class ZPD, of a recognition of local communities of practice, and of negotiated socio-mathematical norms have much to offer in looking at how technology can be used in the classroom. In particular I want to indicate how I have tried to apply these ideas in the development of classroom material and techniques for use with the TI 92 hand-held computer in lower school teaching.

The material

The research discussed here took place in a rural comprehensive school in the UK. The main body of the research was a series of lessons taught by the researcher with one particular class and this will be reported on in a further paper. In addition the researcher was asked to provide most classes in year 9 (age 14-15) with a brief (two one hour lessons) introduction to staff and students of the possibilities of dynamic geometry. This requirement for a short course and for applicability to all ability ranges in the school led to the thinking behind the present paper.
Each student had a TI 92 and an OHP version was available for demonstration by pupils and the teacher to the whole class. The following examples were an attempt to set up possibilities for whole class meaning-making with the minimum of previous knowledge of the TI92. The pattern followed was for the class to generate and discuss a simple dynamic image, and to record the result in exercise books as a diagram after the dynamic image had been appreciated. The hand-held nature of the TI92 is particularly suitable for pair discussion, and indeed, for consigning to a comer of the desk when work on paper is preferred.

The exercises

1. The class were asked to draw a circle and a triangle with its vertices on the circle, then to measure the area of the triangle. They were then asked to investigate the effect of dragging one of the vertices.

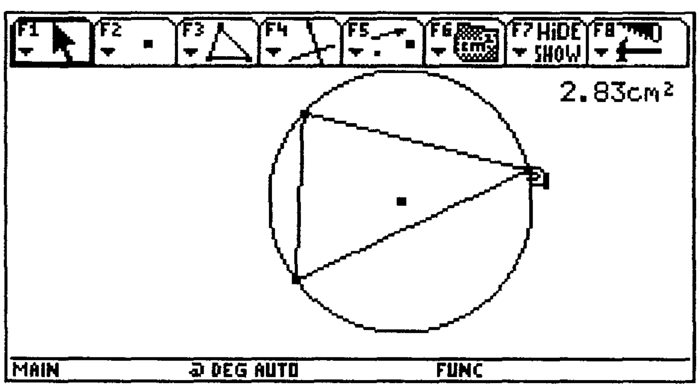

Fig 1.

Questions from the teacher/researcher were first directed at making sure that the class knew that there was no 'right' answer for the maximum area of the triangle. They were then asked to discuss whether there was any conclusion which could be drawn which was common to all their displays when the area of the triangle was a maximum. "What can we all say?" was a question used to unite the class and to try to draw them all into a local community of practice.

2.

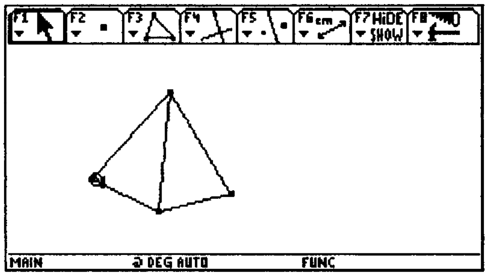

Fig 2.

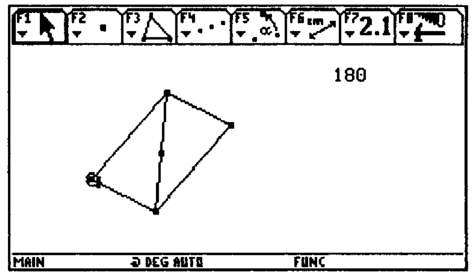

Fig 3.

Figures 2 and 3 illustrate another exercise, again using the minimum of previous knowledge, which seemed to the researcher to generate an opportunity for productive whole class meaning-making. Pupils were asked to draw a triangle (using the Triangle command) and then reflect it in one side (Fig 2) or rotate it through 180 degrees about the mid-point of one side (Fig3) and investigate the quadrilaterals (or triangles in the case of Fig 2) which could be produced by dragging the comers of the original triangle. Again the question "What can we all say?" was used to try to draw the whole class together, before going on to questions such as "How many rhombuses can there be?"

3.

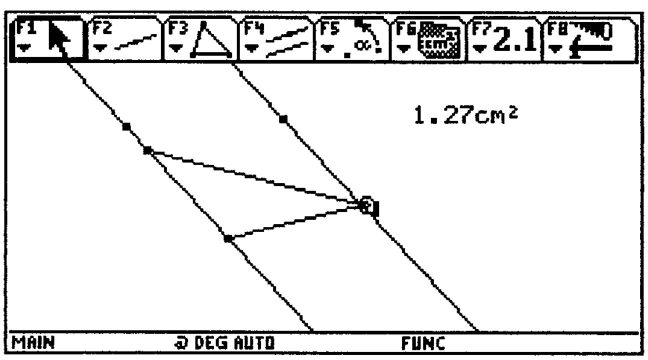

Fig 4.

Another exercise[1] which is available after only the briefest of introductions to the technology is based on a diagram such as Figure 4. Here pupils were asked to draw a triangle with its base on one of a pair of parallels and the vertex on the other. They were asked to investigate the affect on the area of the triangle of moving its defining points.

Conclusion

Lave and Wenger (1991, pl02,103) address the issue of the transparency ofa resource, and this is further examined by Adler (1998, pp8-11). A resource used in a mathematics classroom can be so visible to students that it obscures the mathematics and prevents meaning making. At the same time some visibility is necessary. We want the resource to be visible in the sense that it should direct the gaze of students, so enabling their meaning-making.

'Invisibility of mediating technologies is necessary for allowing focus on, and thus supporting the visibility of, the subject matter. Conversely, visibility of the significance of the technology is necessary for allowing its unproblematic- invisible use. This interplay of conflict and synergy is central to all aspects of learning in practice: it makes the design of supportive artifacts a matter of providing a good balance between these two interacting requirements.' (Lave and Wenger, 1991 pl03)

Clearly the familiarity of students with technology such as the TI 92 governs its use, in a way which is informed by arguments such as this. As they become more familiar with the software the teacher will be able to introduce the use of more complicated functions without losing transparency. In the present case however, with students who had not used the machines before, the same arguments led to the approach outlined above. Questioning such as that outlined above is the stock in trade of many classroom practitioners, but consideration of the issues raised here has helped me to examine why some of my classroom techniques might work, and how I might look for routes to improvement.

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[1] This example owes much to the specimen lesson from a Japanese school discussed, with the subsequent whole-class investigation, in the TIMMS video.(Stigler and Hiebert, 1997) An OHP dynamic image is presented to the class, and the pupils' work is done in exercise books, pointing to an alternative, and perhaps less expensive, approach.

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