AN ACTIVITY APPROACH TO TEACHING AND ASSESSMENT.

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I have briefly indicated some key developments in the history of materialist dialectics and some principles of activity theory which follow from them. I have illustrated these general notions with some references to a program of teaching and dynamic assessment that I introduced in an earlier paper (Day 1998). *I have presented video typescripts together with some quantitative and qualitative data from my research to show that differences in ability between children from different socioeconomic areas were increased rather than decreased in the course of the teaching program. This was shown clearly in data from both static and dynamic assessments.*

Some key developments in the history of materialist dialectics:

I1yenkov (1974) has traced some of the aspects of the history of materialist dialectics which have been important in the development of activity theory. Previous logic had proved to be incapable of tackling the problems posed by rapidly developing scientific theory. In particular, if it was to be of use in the *development* of new knowledge, logic had to be able to tackle the problem of the identity of thought and reality, or truth, in a changing world. Some questions posed for the logicians were clearly nonsensical. For example the question: "What is the distance between the syllable 'a' and a table" asks us to compare the two in terms of a third, space, but the syllable 'a' is not definable by its position in space. The problem of connecting theory and practice, however, was real and important. Descartes (1596 - 1650) had looked for such a third term under which we *could* compare knowledge with subject matter, ideas with things, so that the two could be theoretically related in a judgement. How, for example, could one compare £100 in the pocket with £100 in the mind, or a line on a graph with an algebraic formula? He concluded that there was no third term that could be found to relate them. Only "God" could explain the connection.
Spinoza (1632 - 77) saw that the problem had been wrongly posed. There were not two objects, thought and substance, but only one. This was the real thinking person considered from two different opposing aspects. For Spinoza, the third term uniting concepts and reality was nature. *If nature were only geometric forms, then one essential aspect would be missing from nature. Thinking would be imperfect and mechanistic because thought would be missing from nature.* Nature extends into space and thinks. A thoughtful woman with £100 to spend could trace this material action mentally before carrying it out in practice. Planning and spending here are seen as two attributes of nature rather than as ideal and real properties of the woman.

Kant (1724 - 1804) returned to the problem of developing logic. For him, also, logic had to be concerned with the problem of what thought is and how it is related to the world. If I asserted on the basis of past experience that all swans were white and then discovered a black swan, my whole idea of swan would have to be reassessed. A new broader definition would have to be produced to accommodate this discovery and this new definition would contradict the old one. All judgements of experience without exception have this *synthetic* character and have the right to subsume under a concept facts which contradict the original definition. An *empirical* generalisation is true "a posteriori" in that it can only say with certainty that 'all swans we have met so far are white'. Any inductive scientific generalisation will always be open to contradiction on the basis of new experience. General logic was thus competent only to judge *analytical* statements, in which the original idea was clarified and not *synthetic* statements which may be contradicted by experience. Kant proposed a "Transcendental Logic" of truth, in which synthetic judgements could be made and new predicates added to a concept without breaking the laws of identity and contradiction.

I1yenkov (1974) has pointed out that if this experience is not considered in some arbitrarily determined part, but is taken as a whole, it will include a synthesis of judgements made according to categories that are not merely different but which are directly opposite and antinomic. The category of identity, for example, orients the intellect to invariance in the form of notions such as rate of flow of a river. The category of difference orients the intellect to the discovery of differences in objects seemingly identical. Infinite fluctuations could be discovered in the rate of flow of the river due to rocks in the river bed, the erosion and constantly changing contours of its banks and so on. One or other category must be ignored in making a judgement that is not internally contradictory and this problem recurs throughout all of Kant's categories.

For Hegel (1770 - 1831), Kantian logic was still too limited. If it were to be a real science, logic would have to provide a much fuller concrete exposition of thought. For Hegel, thought had to be a rigorous reflection of *activity* and the sole task of logic was the clarification of the schemas of this reflection. Thought could not be presented to an observer immediately in the form of external or internal speech. It could not be identified simply with linguistic activity and logic could not be identified with the analysis of language. Man did not only function as a thinking being when talking. In fact, he often demonstrated his mode of thinking more adequately in his actions than in his explanations of them. For Hegel the forms of man's became embedded in materials in the process of man's activity and he consequently viewed history as a process of the embodiment oflogic.

Marx (1818 - 83) substituted the notion of social activity for Spinoza's notion of "Nature". He argued with Hegel that the accumulated knowledge of generations should not be allowed to confront man as a collection of alien objects. This alienation could be overcome if the knowledge were appropriated by men as a tool for use in productive activity.

Vygotsky (1934/1986) tried to limit the development of a science of materialist dialectics to the development of a synthesis of traditional and progressive notions of development. The notion of analytic induction forms the core of Piagef s theory of equilibration. A spontaneously occurring theoretical construct is tested in practice until a contradiction is found and the need to accommodate the contradiction leads to modification of the theory. A child will swat an irritating fly landing on her arm once and then will be able to do this for other flies. When a hornet arrives and she swats it she may well be stung and a new predicate will be added to irritating flying objects. Vygotsky has noted that a central problem with Piaget' s notion of equilibration is to be found in empirical studies showing that, contrary to Piaget' s assumption, awareness of difference or contradiction is actually easier to achieve than awareness of similarity because the latter awareness requires a more general notion under which the similar objects can be compared. It is easier to distinguish between a fly and a hornet than to form a general notion of a fly. A dialectical synthesis would have to incorporate both inductive and deductive processes as moments in the development of this theory.

Gal'perin (1976b/89, 1980) pointed out that although this analysis was basically sound, unless activity theory could explain how activity was developed in practice it was in danger of returning logical development to rationalistic dualism. He subsequently investigated the logical development of thought as an integrated duality in the process of appropriation of orientation and executive actions. He argued that logical concepts (thoughts about thoughts) are developed from a combination of executive and checking actions to constitute what we later recognise as intuitive understanding and "attention".

In traditional teaching practices general mathematical notions such as "fractions" or "algebra" are often taught separately from practical applications with the result that students have problems developing a conceptual mathematical knowledge that can orient them towards the solution of problems they encounter. The search for the solution of a problem without this orienting basis for action can lead to an inefficient "trial and error" strategy in problem solution. Activity theory involves the use of the continually changing nature of the meaning of words or language to link together general and particular notions. In this process the student comes to see, remember, attend to and generally conceptualise the notions as they are encountered in practical problems in the same way as an experienced mathematician, such as the teacher, would conceptualise them. This includes appropriation of the rational form of the quantities. It must also include an orienting base for the actions to enable the student to use this ability in solving problems.

An integrated program of teaching and dynamic assessment.

I prepared a series of lessons based on a translation I made of a study by G. Nikola, presented in books by N Talyzina (1981,1995). This program modelled the notion of "Rate" as an introduction to the theory of mathematical functions. The rational form and a scheme for the orienting base were presented in written form in cards and in trees of reason. These two aspects of the teaching were introduced in written form so that they could be used immediately without artificial memorisation. Problems were presented in a carefully prepared program designed to lead the student through a process of abstraction and condensation in which the language used came to embody executive, orientation and control functions as conceptual models of the notions presented in the cards.

Stage one involved the checking and consolidation of basic knowledge, the use of linear and graphical models and an introduction to the novel form of the lessons, including the use of card 1 to introduce work in forming an orienting base for actions. This was essentially a system of instructions which demonstrated how actions should be carried out but did not yet enable the pupils to act independently.

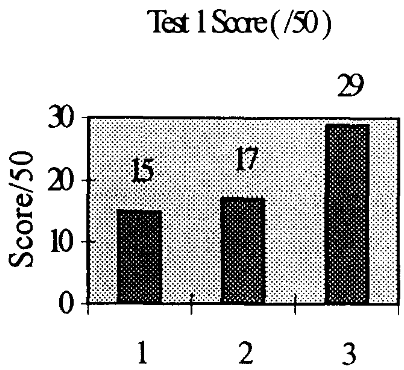
Stage two involved the development of actions in materialised form with extensive specification of all orientation, executive and control functions for all variables. Cards one and two were used in the solution of examples that included all possible combinations of the three general notions of time, rate and product of the processes. This stage also included presentation of a wide variety of examples in a way that required some combination of both material and verbal activity. In particular this involved the use of examples with missing variables that were therefore impossible to solve, extra variables that had to be consciously ignored and the construction of examples by the children themselves.

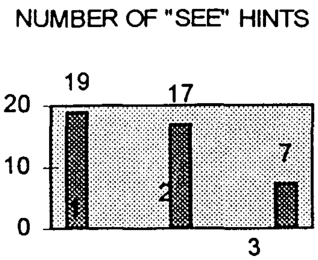
In stage three actions were developed in the form of (written or spoken) external speech. These were still neither automatic nor condensed actions. Card three was introduced together with action diagrams built into trees of reasoning in order to enable the formation of more complex actions, which could be pictured immediately through a number of progressively more highly focused layers of definition. Examples at this stage were designed to ensure that the speech became an independent embodiment of both general notions and concrete actions. For example, Vi would come to be seen automatically as the rate of output of a particular pump or the wage of a person, depending on the question in which it appeared. The children were required to continue the practice of constructing their own examples and abstract practice was introduced both as the object of certain lessons and in all subsequent ones.

In this way they moved 011 to stage four of the process in which actions were developed as unvoiced external speech. Actions began rapidly to experience condensation and automation and acquired a form of operation conforming to an algebraic formula. It was possible for a student reaching this stage of development to reply immediately, for example, that a man running at 4 mps for 10 seconds would cover a distance of 40 metres. Stage five of the appropriation process, in which the actions became so automatic that they were inaccessible to introspection, was clearly reached in many cases but I stopped at this point to investigate proximal development zones. Qualitative and Quantitative Assessment.

I have developed a two-stage dynamic assessment procedure that will partially quantify this learning process. The lessons are recorded on video in order to monitor conceptual development. Following teacher explanation, the researcher focuses on a particular student and helps with the work *slhe* is doing. The video record is reviewed immediately after the lesson so that adjustments to the individual work program can be made before the next session. In the dynamic assessment, following a course of instruction that provided a well defined context, clearly understood by both student and teacher, the researcher sits with each child for about an hour and works with him or her to complete a discourse structured around the completion of a theoretically based series of practice papers. In this way we can obtain both qualitative and quantitative measures of conceptual development (as opposed to notional understanding) and hence evaluate the success of the teaching process in developing problem solving ability within the field of instruction (Day 1998).

Qualitative video analysis showed a marked change in attitude from the initial introductory stages one and two, which were more traditional in form, to the second phase in which conceptualisation was developed. There was a great increase in interest and involvement in all three schools and a level of enjoyment and value attributed to the work that I have rarely seen in English schools. Children in the study were aged eleven or twelve and were considered by their schools to be working on levels three to five of the national curriculum. They scored on average 63% in a level 3/5 SAT paper at the beginning of the program. Problems set in topic tests t 1 and t2 at the end of the program were of the sort presented at GCSE levels 7 - 10. Scores ranged from 42% on average in test 1 to 52% on average in test 2, after one hour of individual tuition. I stopped the teaching process before the stage of 'fluency' was reached by most pupils in order to carry out the dynamic assessment. The children from the "poorer" schools (1 and 2) started behind their peers and fell further behind on both static and dynamic measures. The charts on the next page show static and (inverse) dynamic measures of average performance in three schools at the end of the teaching.





Static test scores for schools 1 - 3 Dynamic scores (measuring inversely) for schools 1 - 3

Although the power of activity theory to generate innovation in teaching and assessing mathematics has been clearly demonstrated, there were a number a children who failed to achieve the target set for fluency in the domain. This failure was due partly to insufficient flexibility in the teaching program which could meet the needs arising from the social variation built into my sample. In particular the central aim of ensuring successful completion of checking and control aspects of the activity proved problematic because of this variation. It seems likely that a more sophisticated individualised teaching program using techniques from established schemes such as 'SMILE' mathematics will be needed to overcome these problems and research to develop such a program is currently under consideration.

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