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A VYGOTSKIAN APPROACH TO MEASURING ACHIEVEMENT

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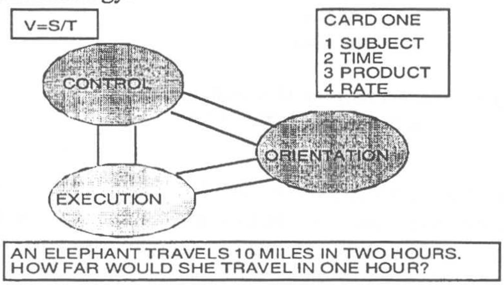
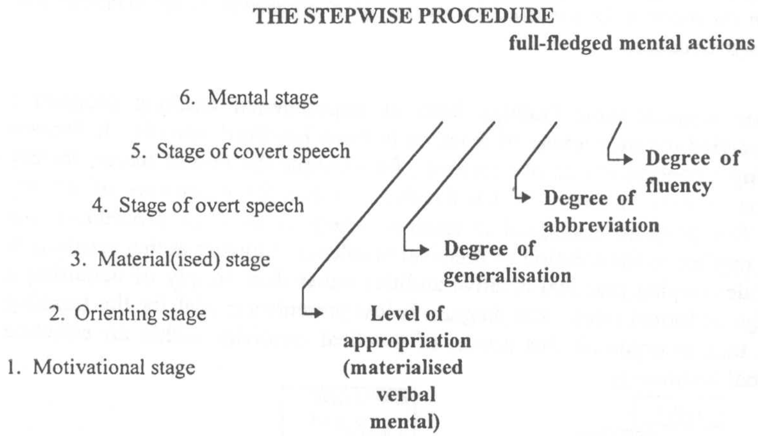
I will present some results from a teaching program in which a child scored poorly both on quantitative static tests and in a dynamic assessment procedure which indicated a low level of fluency. I will suggest that the developing buds of her ability did, however, become clearer in a video record. I will argue that the developing fruits of learning, and the child's potential or readiness for further work, can be more fully assessed by means of a combination of dynamic and qualitative procedures.

This paper presents some findings from an experimental teaching program I recently carried out over a year of research in three Bradford schools. It focused on teaching a concept of rate of processes, for example the rate of travel, factory production or flow in water. It was developed within the framework of activity theory. The program attempted to teach a variety of complex procedures that could be applied to the solution of practical problems. I looked at this learning in terms of developing practical creative abilities rather than simply of acquiring a knowledge of formal rules. The diagram below presents a model for the teaching program that incorporates this notion of practical creativity within an effective educational technology.



In this diagram, formal mathematical notions are depicted as models which act as a control for practical actions. An example of a practical action could be: 'An elephant travels 10 miles in 2 hours. How far would she travel in one hour?' The third area refers to a process of orientation, of knowing what to do next at any point. It is taught in this initial example by means of a card which indicates the main operations to carry out in simple calculations and the order in which to do them. These instructions were operations in verbal form. They were abbreviated during practice to a coded form '1,2,3,4' and then, with more practice, to a simple 'awareness' of what to do next, or 'attention'. The next diagram shows in more detail how the generalising function of language is the main driving force for this new technology. Practical actions are converted to words and then to mental actions. This takes place in a continuous ongoing manner in a number of stages: a motivational introduction; an orienting stage; a stage for presentation of actions materialised in diagrams; an overt speech stage in which actions change to a verbal form as they are spoken aloud; a covert speech stage in which the speech 'to oneself' is abbreviated and condensed; and a final stage of 'pure thought' that is not accessible to introspection.



Stages in the formation of mental actions
(from Haenen, J. 1996 p. 134)

The teaching program was recorded on video. At the end of the program I also looked both at what the children could do unaided and at what they could do in co-operation with a more capable adult. In this dynamic assessment, two similar formal tests were separated by three practice papers. Theoretically based hints, generated from the teaching program, were given during the practice papers until all the problems were solved. Mathematical gains over the practice session were defined by residual gains in test two, above or below what was predicted by the overall trend of results. I found that the greater the amount of help that was needed in completing the practice papers, the lower the gains that were made during practice. Also, the amount of help needed was an important factor in predicting these gains.

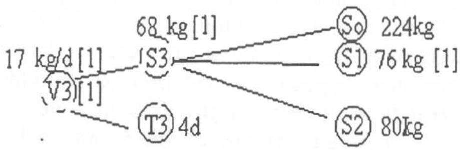
In a multiple regression, the number of hints (hts) accounted for 17% of variation in residual gain scores over and above general mathematics ability, background factors and a specific test of the work we had covered. Help was mostly given in more complex questions when assistance was needed to conceptualise part of a problem in a way that led to a solution. I concluded that the degree of fluency and mastery of the generalised actions, as indicated (inversely) by the number of hints given during practice, was an important factor in producing mathematical gains.

The quantitative data refers to a structured sample generated by choosing schools in the city from mean and quartile positions in terms of the percentage of free school meals. The correlational analysis then looked at input and output variables that summarise particular aspects of the children's lives. Independent variables ma (summarising general maths ability), iq (summarising general background factors), t (summarising completed appropriation of actions), or hts (summarising the appropriation of actions that can only be completed with help) were chosen. These were investigated as predictors of a dependent variable rg (summarising the residual gains following an hour of individual tuition). The aim of this process was to test the strength of the relationship between the input and output variables.

The students in the study were not simply responding to the teacher, to the work, or to 'internal' motivation. They were interacting with all significant others that were seen as relevant to the teaching and learning process. The children checked each others work, showed their feelings about how the work was going, and worked towards objectives that appeared in the context in which they were situated. Dividing this real flow of relationships into discrete variables partly obscured the relation of measured actions to their practical content. The correlational findings were found to be useful numerical summaries. They were not, however, expected to fully describe the educational interactions that led to the changes and the correlated scores were viewed merely as general indices of social practice produced in a dynamic interaction.

Because of these limitations, it would have been difficult to discover explanatory factors using numerical summaries alone. Questions like: 'How well do the children carry out the checking procedures?'; or 'Are the whole class checks on control activity effective?' which arose in viewing the overall flow of the interaction could not be recovered from the numerical summaries. In the numerical summaries, some of the data was lost and it was thus difficult for a reader to construct alternative explanations for the data. In order to show how the general summary of the whole sample developed at a number of levels, from whole class interactions to a focus on individual students, a more qualitative description was necessary. Objective facts such as indices of fluency (hts) that were obtained as the result of classroom interactions, were investigated qualitatively within these interactions. The qualitative data was selected after the quantitative analysis, according to different criteria from those used to select the quantitative data. The qualitative sampling was purposive and theoretically based, selected because of the relevance it had to my central research question. This was to look for ways of introducing equality of educational opportunity into the three schools involved in the program. I found, for example, that fluency was a factor that could lead to difficulties in interpreting test papers. In the final test the more advanced students worked rapidly in abbreviated mental form and produced only completed answers. These answers appeared as if by magic and could only be marked right or wrong. The detailed working, shown below in expanded form, was often not accessible.

A sample test question as answered by a student:
Three children collected 224 kg of potatoes working together for 4 days. In this time Amanda collected 76kg and Kelly collected 80 kg. They continued at the same work rate for the next six days, but Arfan doubled his work rate. How many kilograms did he collect in the next six days?
Ans: 204 kg
The same sample question with an expanded answer and mark scheme, using Talyzina's (1995) 'tree of reasoning' notation:



New V3 = 2 x 17 kg/d = 34 kg/d.

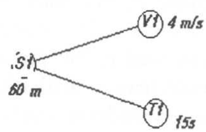
[1] [1]

New S3 = V3 x T3 = 6d x 34kg/d = 204 kg

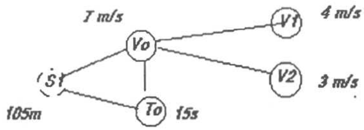
[1] [1] (8 marks)

Looking through earlier video records did, however, enable me to look at such expanded working directly. The next diagrams focus upon a single frame taken from a video record of one of the earlier lessons. It shows, for example, how a simple task became problematic when fluency was not developed early on. Diane scored poorly in the tests and the dynamic assessment indicated a low level of fluency. The developing buds of her ability were, however, clear in the video record. Diane missed the simple correct solution (Gemma's distance is her speed multiplied by her time) and arrived at a more complex version (adding rates and then working in terms of overall quantities for speed and time).
Two children run towards each other. Gemma runs at 4 m/s and Tamarra runs at 3 m/s. They meet after 15 seconds. How far did Gemma run?

The correct solution diagram:



Diane's solution:



Diane had understood that adding rates (V1 +V2) was a possible action. She also saw that given the overall rate of running (Vo), overall time (To) could be combined in some way to continue the calculation. The diagram from the video record shows how her reasoning broke down here. The problems with her final action could be summarised in terms of:

1) ORIENTATION (Knowing what to do next): When combined speed and time had been found Diane could have calculated total distance covered and this would have lead her back to the simple calculation. She would have realised that finding So (overall rate) was not helpful here and reviewed her options, probably then arriving at the simple solution above. She lacked a fluency or mastery that would enable her to do this in the time she felt to be available.
2) EXECUTION: Diane panicked and guessed (wrongly) that the final answer (Gemma's distance, S1) could be found straight away.
3) CONTROL: Checking the action against a model (So = To x Vo) was not carried out. Future actions would be likely to follow this trial and error strategy. As she did not discard the incorrect solution (S1), Diane was developing a fluent practice incorporating an incorrect strategy that would become the form of her future abbreviated acts of control or 'attention'.

This meant that fluency of correct control actions (or insightful attention) was not developed. I had not simply asked the children how they had felt in carrying out the work because the questions I could ask would themselves structure the answers they would give. The children's memories would also be selective and would have been constructed from notions that they were not consciously aware of, notions which could not be articulated or observed. The video records of the lessons provided a record preserving the data in a form close to the original. The resultant transcripts preserved access to the original material without relying on the memory of either participants or researcher. These tapes and transcripts are thus intended as a public record, available to the scientific community. Since they are also open to further investigation by the reader, they can later be looked at in different ways and improved on.

In our conference session we watched about five minutes of the video. We then focused more directly on a transcript of part of this record, containing the frame I have been discussing. The video record showed how I helped Diane to correct her problem and how she was able to make great progress in catching up given this dynamic assistance. The guidance I gave substituted for the fluency she lacked. Her achievements were thus not only measured sympathetically, they also revealed ways to help her improve. This could be achieved by reducing time pressure, by introducing more structured control procedures in future lessons and by introducing a work scheme that could be used individually or in small groups.

In this way qualitative and quantitative dynamic assessment procedures have been used to investigate the nature of collaborative activity in order to assess the psychological functions that are currently maturing. The resulting analysis has been used to evaluate the products of a teaching and learning situation and to provide indices that will help to guide the development of future programs. Simply looking at test and examination data in isolation could not provide this diagnostic help.

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