Activity R

Teaching Ideas and Evidence through 'Forces' in Year 8:

Incorporating Higher Level Thinking Skills into Science Teaching

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The Project

Over a period of six weeks, a Y8 science top set was given a number of different tasks that incorporated higher level thinking skills according to Bloom's Taxonomy. The effect of such tasks on the pupils' motivation was analysed and evaluated. Three of these tasks are presented here.

One of the ways of fostering gifted pupils is to engage them in challenging thinking, e.g. by letting them apply previous knowledge in a different context. Such tasks are presented here. Two of the tasks are an introduction to a new topic (moments and pressure respectively), and the other is an investigation into the practical application of the principle of moments. Instead of presenting the pupils with facts to memorise (rote learning), they had to develop their own ideas and find the laws. Daily life experience had to be applied to new tasks. Formulating their findings mathematically was a further step of abstraction. Higher level thinking skills are defined here as all levels above level 2 in Bloom's taxonomy (table 1).

The pupils' motivation was analysed through two questionnaires and an individual interview.

Tasks

1. A DART (Directed Activity Related to Text) activity on balances as an introduction to moments (appendix 1). Pupils had to solve the questions in two attempts – first from their own experience, then through experiments with a balance and masses. At the end of the task they were asked to express the laws they found both in words and mathematically. The DART activity in appendix 1 is a modified CASE (Cognitive Acceleration through Science Education) worksheet.

- An investigation on examples of moments in the classroom (appendix 2). The moment is calculated by measuring the force and the distance. Errors have to be considered and a write-up is produced. Time limited to 50 minutes.
- A DART activity on pressure similar to the first task. Pupils make predictions and test them through experiments (appendix 3). The relationship between force, area and pressure has to be expressed both in words and as a mathematical formula. The DART in appendix 3 is an improved version of the original in appendix 4.

Outcomes

Thinking Skills

Overall, in all tasks, pupils did employ higher level thinking skills. In the DART activities the levels reached were particularly high.

1. The class average for correct answers on the CASE worksheet was 54%, and the best scoring pupil obtained 95%. It can be anticipated that the percentage of thinking at higher levels was higher than 54% suggests. (The probability of gaining a correct answer by guessing is far lower than the probability to get a wrong answer in spite of thinking at a high level.)

2. The levels of thinking (according to Bloom) required by the CASE worksheet questions were analysed, and pupils' answers were evaluated.

Level (Bloom)	3 (application)	4 (analysis)	5 (synthesis)	6 (evaluation)
Reached by % of pupils	56%	50%	54%	12%

   These results certainly exceed the thinking challenge of average teaching, which can over-emphasise knowledge and comprehension.

3. The investigation on applying moments demonstrates only a little higher level thinking. Pupils did not seem to be used to working on such an independent basis. A good example for this lack of independent thinking is the standard evaluation phrase "To make it a fairer test I would repeat the experiment more often." Appendix 4 shows two of the best examples. The highest level of thinking that pupils achieved was level 3 – application.

4. The DART on pressure was a good introduction into the topic since the pupils could develop their ideas and test them. The pupils seemed to grasp the concept more quickly compared to the similar exercise on moments. The class average for correct answers was 69%, and two pupils achieved 100%.

Level (Bloom)	3 (application)	4 (analysis)	5 (synthesis)
Reached by % of pupils	49%	45%	8%

A disadvantage of this exercise is that pressure and depth of impression are only proportional in the sense of an initial, rough estimate. The depth of the impression is not easy to measure and time is an additional factor. Therefore the results are not as clear compared to the balance exercises. Two samples of pupils' work are presented in appendix 4.

5. The determination of levels of thinking is somewhat subjective. The results might therefore slightly differ if someone else determined the levels. However, these results strongly suggest that higher level thinking skills were reached by large proportion of pupils.

Motivation

The majority of pupils stated when interviewed that they liked their thinking to be challenged. The interviews were held after the sequence of lessons when the thinking challenges had been completed.

- Pupils are not used to higher level thinking tasks. Initially they showed resistance, but once they realised that they were capable of solving the questions they gained confidence.
- In the interviews, 77% of pupils indicated that they liked their thinking to be challenged. A few of them said that they strongly disliked tasks in which they thought they could not succeed.

Professional development benefits

In terms of my own professional development I found it helpful to gain experience with higher level thinking skills exercises and pupils' responses to such tasks. It helped me develop my skills at gauging the right level of challenge when setting such tasks.

Recommendations

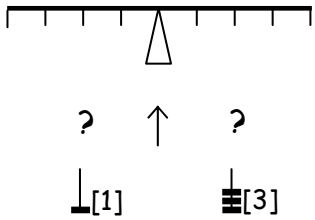
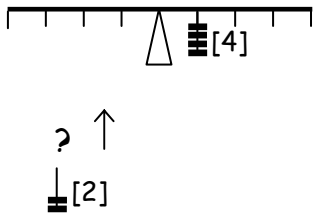
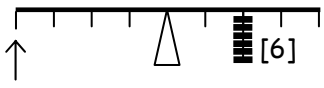
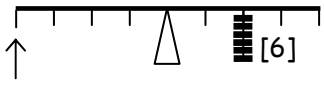
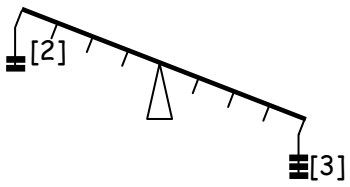
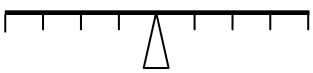
- To foster higher level thinking skills a 'thinking culture' needs to be developed. The attempt at, rather than the success of, solving problems has to be encouraged and valued over a long period of time. Pupils do not start thinking at high levels over night.
- The development of such a culture can be achieved by including exercises like the investigation on application of moments. With more exercises and formative feedback, I would expect gifted pupils to broaden their approach and thinking.
- Initially, thinking skills can be developed through tasks that involve a lot of guidance or a step-by-step approach that leads the pupils' thinking (as in appendix 1 and 3). In the long run, open-ended tasks can be more successful if it is the thinking itself that comes to be valued, even if the answers are incorrect.
- A simple way to encourage pupils' thinking is to use open questions. Here again the teacher's valuing of good thinking rather than correctness is vital.

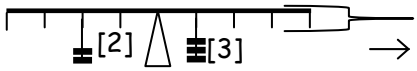
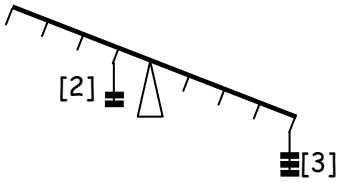
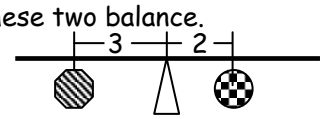
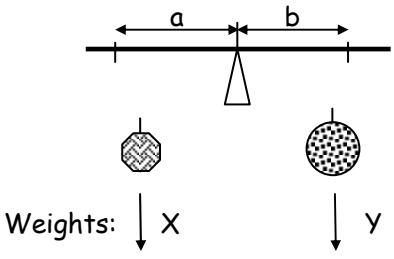
References:

Adey, P.S., Shayer, M. and Yates, C. (1995) *Thinking Science: The Curriculum Materials of the CASE Project* (second edition), London: Nelson.

Bloom, B.S. (ed.) (1956) Taxonomy of Educational Objectives: Handbook 1 (Cognitive Domain), London: Longman.

Balancing out

Question	1st Attempt: Prediction	2nd Attempt: Checked through Experiment
1.) Place the weights in such a way that they balance each other out! 	 Explain:	
2.) 	 Explain:	
3.) If I add 100g to the 400g in 2.) how much must I add to the 200g to keep it balanced?	1st answer:	2nd answer:
4.) If I move the 400g in 2.) to position 2, to which position must I move the 200g?	1st answer:	2nd answer:
5.) What must I hang in this position to make this balance?		
6.) Move the weights so that they balance each other out! 		

7.) If the clamp on the right is removed, how will the balance look? Draw! 		
8.) Leave the hangers where they are, but shift the weights so that balance is achieved! 		
9.) These are in balance. If I move the [3] one unit away from the centre, how far must I move the [2] to keep the balance? 	1st answer:	2nd answer:
10.) These two balance.  a) Which one is heavier? b) How much heavier is it?	1st answer: a) b)	2nd answer: a) b)
11.) Can you give a general rule which connects weights and distances and whether the system balances? 		
12.) Can you describe your rule with a formula?		

Moments in the Classroom

(An Investigation)

Aim: Calculate a moment in the classroom.

Planning

- What do you need to measure?
- How do you measure it?
- How fair will your test be?
- Estimate where errors could come in and how accurate your test is. Should you have different opinions in your group, describe the different view points! Come to your own conclusion!

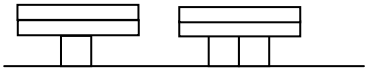
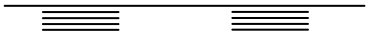
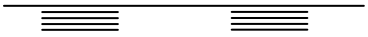
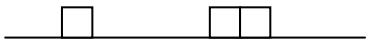
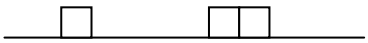
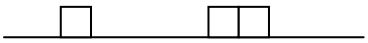
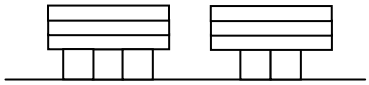
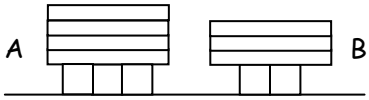
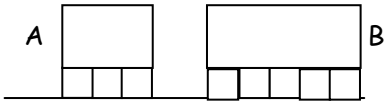
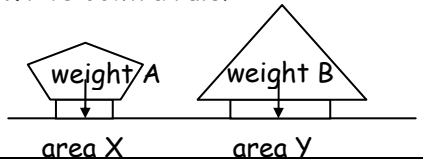
Results

- Sketch of the measured moment
- Results

Evaluation

- How reliable are your results?
- Discuss any errors that could be in the results!
- How could you improve?

Pressure

Question	1st Attempt: Prediction	2nd Attempt: Checked through Experiment
1. Draw how deep the two set-ups will be sunk into the play dough after one minute! 		
2. In which of the experiments will the cubes sink deepest into the plasticine? Explain!		
3. If 100g are added on top of one cube, how much has to be placed on top of 4 cubes to let them sink into the material to the same extent? Draw and explain! 		
4. Add so many weights on the left that the pressure will be the same as on the right.		
5. Where will be the higher pressure? Under A or B? Explain! 		
6. Both exert the same pressure on the plasticine. How much heavier is B than A? 		
7. Both shapes leave the same impression on the plasticine. Write down a rule! 		

8. Express your rule as a formula.		
9. Challenge: it is said that the pressure on the tip of a pin is higher than on its flat side. Is there any way you can prove this with plasticine? Draw and explain!		
10. From what you know about pressure so far try to understand how the apparatus works. Explain and suggest what it could be used for.