Critical thinking and problem solving in chemistry examinations.

In recent years there has been an increasing emphasis on problem solving in chemistry exams at FHEQ levels 6 and 7. External examiners explicitly look for problem solving questions and sometimes complain if there is even a single question where they cannot identify a problem solving component. At accreditation we also look for problem solving at both levels.

At Oxford we use the Cambridge Assessments TSA test (Think Skills Aptitude) as part of our admissions process. This test explicitly identifies separate marks for problem solving (numerical and spatial) and critical thinking (understanding argument and reasoning). In the 600 or so candidates who take this test for Chemistry at Oxford each year we have identified a consistent gender disparity in the problem solving score, with men outperforming women by between 2.5 and 3.5%. The difference is statistically significant, varying from 2 to 3 standard errors, depending on the cohort. However, there is no significant gender difference in the Critical Thinking score. There is a similar consistent gender difference in our own examinations, which are heavily based on problem solving, and at A' level Chemistry, where a higher proportion of men than women are awarded A*.

A possible hypothesis is that the pendulum in examinations has swung too far towards numerical and spatial problem solving, to the detriment of other skills. For example, in many of our exam questions there is a "Comment on your result" rider, which not treated as seriously as the rest of the problem, either by the examiners or the students. FHEQ requirements clearly include both components – for example at level 6 we should test the ability to "critically evaluate arguments, assumptions, abstract concepts and data (that may be incomplete), to make judgements, and to frame appropriate questions to achieve a solution - or identify a range of solutions - to a problem."

It would be interesting to have a discussion about this issue, for example

- the extent to which critical thinking should a part of our examination design,
- how to analyse an exam to identify this component,
- how to write exam questions to test for both critical thinking and problem solving.

Some possible things to look for are:

- Interpretation of data and scientific evidence
- Reasoning, identifying and articulating logical connections
- Appropriate choice of evidence to justify ideas, construction of an argument
- Joining up ideas from different parts of the subject.

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