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WHY STUDENTS FIND O-LEVEL QUALITATIVE ANALYSIS DIFFICULT?

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In qualitative analysis (QA), students are required to carry out a series of procedures using chemicals, apparatus and appropriate techniques. They then have to observe and record what happens, and make inferences based on their observations. Thus QA involves manipulative, observational, recording and inferential skills. It also requires students to apply what they have learned in topics such as "Acids, Bases and Salts", "Oxidation and Reduction", "Reactivity of Metals" and "Periodicity" to make sense of the experimental procedures and results.

Many teachers find that upper secondary chemistry students do not understand what they are doing in the QA laboratory sessions. Teachers also frequently complain that students adopt a recipe-approach, cannot seem to carry out the experimental procedures properly, and do not understand the purpose of the experiments.

Many students, on the other hand, do not like QA practical work. They find it tedious and boring to do the "same thing over and over again". This is because they will have about 10 to 15 sessions of QA experiments, often week after week. Students also find it tedious to carry out the many procedures required in the experiments, especially when testing for gases. They fear four things in QA experiments. These are not getting the anticipated results, getting results which are different from those of their classmates, not knowing whether the results obtained are correct, and getting results for different parts of the experiment which do not tally with each other. They also feel that QA involves a lot of memory work, and that one will do well if one can memorise the data sheets in QA.

WHY DO STUDENTS FIND O-LEVEL QA DIFFICULT?

Firstly, students often do not know what they are doing in the QA experiments. Tasker and Freyberg (1985), in their study of practical work in school, wrote:

> Our observations have shown that pupils did not have any idea of what were the critical scientific factors in the experiment, even though teachers assumed that they did. Pupils had little appreciation for features in the design of an investigation and consequently no real basis for anticipating the nature of its outcome. (p. 71)

In a study involving interviews, students mentioned that when they had to test for gases, they did not know which gases to test for in a given situation, and hence they randomly tested for all the required gases in the syllabus. This resulted in them wasting time testing for the "wrong" gases, and using up all the gas evolved before they could complete all the tests. They also said that they often had no idea why they were instructed to use a certain reagent or what they were testing for, what were the reactions which occurred or why they obtained a particular result. Pintrich et al. (1993) state that the student's belief that he/she can accomplish a task motivates him/her to be cognitively involved in the task. Unfortunately, students seemed to feel helpless and directionless in QA and this might affect their learning of it.

Secondly, students seem to have problems in carrying out the procedures involved in QA. This can be seen by the way some students add reagents to the unknown; instead of adding drop by drop at the beginning, they add to excess in one go. Other procedures which are often haphazardly done are heating and testing for gases. However, teachers may have to bear some of the blame for the lack of students' proper technique. Herron (1996) wrote:

> We seldom make deliberate efforts to teach laboratory skills that, much to our chagrin, students have never learned. By teaching, I do not mean telling students what to do or performing a quick demonstration in front of the class. I mean carefully prepared lessons, with clear statements of expectation, feedback to individual students so that they can correct errors, and evaluation at the end of instruction to be sure that the lesson is learned. I am talking about doing what any good coach would do in teaching a psychomotor skill. (p. 20)

Do teachers explicitly teach students skills such as how to dissolve substances, add reagents, test gases, and heat substances? Do teachers take time and care to ensure that their students practise and master the procedures required in QA? Many do not.

Thirdly, students may be overwhelmed by the activities in QA experiments. Johnstone and Wham (1982) have suggested that there is too much "noise" in practical work. They argue that the working memory of students is bombarded with information of various kinds, such as written and verbal instructions, new manipulative skills, unfamiliar labelling of reagents, and inputs from the experiment itself, such as visible changes, new smells and gases given off. In addition the students have to recall manipulative skills and background theory, and associate names for apparatus and reagents. This is definitely true for QA as students need to read instructions, carry them out, prepare additional tests, observe, record and interpret their results, as well as being mindful of the time left to complete the experiments and their reports. Overloading of the working memory leaves "no space for thought and organisation and so faulty (or even no) learning takes place" (Johnstone, 1984, p. 847).

Fourthly, the content of QA is difficult. Students do not encounter qualitative analysis in normal everyday life, only in the laboratory, so they have virtually no conception of it. The concepts behind the procedures in QA and the reactions that occur are abstract, complex and extensively linked to other concepts. For example, Fensham (1994) points out students find what happens when substances are heated confusing because the substance may dehydrate, decompose, change its state, or undergo a combination of the processes! QA also involves a mix of knowledge and skills, such as propositional and procedural knowledge, and manipulative and inferential skills. Thus it is not surprising that students find QA very demanding and difficult.

Finally, students' motivational beliefs about themselves could facilitate or hinder learning. The goals, interest, self-efficacy and control beliefs of students (Pintrich, Marx & Boyle, 1993) affect students' learning of QA. Teachers know that the goal of many students is to get good results rather than understand what they are learning. This is to be expected. However it is sad to say that teachers may also have this performance goal for their students. Teachers may be more concerned about students getting good results than understand what they are doing, and concentrate more on doing past years' examination questions and on "model" answers rather than on thinking and understanding. Many students do not enjoy coming to the laboratory sessions and doing the experiments. To them, it is a frustrating exercise because they cannot seem to get the "correct" answers that teachers expect. Teachers may even heighten the tension in the laboratory by focussing mainly on what their students do wrong than what they are doing correctly. Thus instead of firing students' interest in QA, teachers may be dousing it by what they do in the laboratory.

In conclusion, QA is a difficult topic and students may not enjoy the practical sessions. Thus teachers need to help students learn the theory involved, to make the appropriate links between the different concepts involved, and to master the process skills required for the experiments.

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