School labs as sites for fraudulent practice: How can students be dissuaded from fudging?

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Abstract
Fraudulent practices in school laboratories appear to be rife in cookbook style practicals. In this paper, we describe the contexts in which fudging flourishes and suggest some simple strategies which are likely to dissuade students from such undesirable behaviour.

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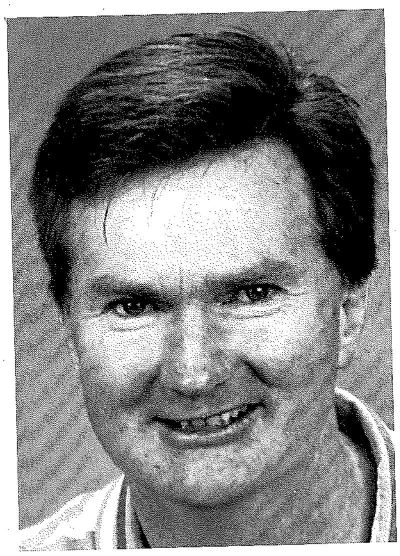

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Introduction

The students in this Year 11 chemistry lab were asked to confirm predicted volumes of reactants in an acid - base neutralisation reaction by titration. With only 10 minutes remaining, there was an air of anxiety among the busy groups. Suddenly, one of the groups panicked when they realised that the expected volume of the titrate had been exceeded. "Who made up the solutions?", "Did we have enough indicator?", "We don't have enough time to repeat the trial", "What have they (referring to a neighbouring group) got?", were among the questions and comments that could be heard above their confused mumbles. In this class, the students knew that marks were awarded for laboratory skills and laboratory reports and they would be hard pressed to account for their 'sloppiness'. Then a single voice whispers convincingly: "Fudge time". Others nod approvingly. As the teacher announces time to clear up, one student hurriedly makes up readings (with built-in variations from the ideal set of results) while the others copy. "That looks about right", another confirms. After cleaning up, they leave content that they have the right data to complete another successful prac report.

Is this a familiar scenario? From our recent studies of laboratory learning (Rigano & Ritchie, 1994; Ritchie & Rigano, 1995, Rigano & Ritchie, 1995) we regret to admit that the hypothetical vignette described above is not just a figment of our imagination. Our research subjects, Year 11 and 12 chemistry and physics students, have confessed to school laboratory practices which are inconsistent with acceptable scientific conventions. We call this behaviour fudging. In this paper we describe some factors which encourage students to fudge laboratory results. More importantly, however, we discuss why some students do not feel the need to fudge. Such revelations have implications for re-designing cookbook laboratory sessions in order to dissuade students from engaging in fraudulent laboratory practices.

Why do students fudge?

As former secondary and undergraduate science students, almost all of us can remember either fudging or seeing other students fudge their results in a laboratory session at one time or another. We don't claim to have stumbled on a 'discovery' which should shock us all; perhaps accounting for the familiarity of the opening vignette. Fordham (1980) alerted us to fraudulent student laboratory practices 16 years ago when he reported the following secondary student's confession:

> If the experiment doesn't work we go to somebody else and get their results... you have to hand it up and it looks better when you get results that you are suppose to. When you read the aim of the experiment you get a good idea of the type of result you are expected to get. And if you don't get that result and you put it down, it's pretty

obvious you won't get as good a mark as someone who got it to work (Fordham, 1980, p. 114).

Within this admission of copying results from other students we are given two reasons to justify the practice. In this case, the student already knew the expected result from the stated aim of the experiment. Verification of an established 'fact' was the expected outcome of the laboratory session. Secondly, we see that the student perceived that a better mark would be achieved if the result was closer to the expected value.

We were reminded of similar practices recently in one of our studies of senior secondary students who were undertaking open-ended research projects in a university setting (Ritchie & Rigano, 1995). In this study, we had been observing the two students encounter persistent problems with time-consuming and repetitive procedures in a chemical engineering laboratory. After about two hours of frustration they realised that one of their solutions was an incorrect dilution and that they would need to repeat the experiment in their following week's visit. At this point one of the students commented that "at school this would be fudge time". During a follow-up interview with both students we found out what these students meant by fudging, what factors contribute to such practice, and the extent of this practice from their experience in school settings. Furthermore, these students were able to illustrate this practice with several examples. Armed with this information we decided to include some questions about fudging in interview protocols with other groups of high school students involved in similar laboratory research projects we were studying (see Rigano & Ritchie, 1995). The data from these studies have been used here for the purposes of identifying student fraudulent practices and the reasons students give to justify such practice.

Like the student interviewed by Fordham (1980), several students we interviewed admitted to checking and even copying results from other students. They didn't perceive this behaviour as stealing or cheating because they had actually carried out the experiment. Instead, they justified it in terms of data verification. We too, value data verification between groups and recognise the potential for learning as students negotiate the meaning of discrepant results. However, we baulk at the practice of exchanging or copying results without engaging in dialogue about the possible reasons for the anomalies.

Seven of the nine Year 12 students we interviewed, these were students from six different schools, representing both state and private systems, admitted to adjusting their results to fit expected rather than actual results. Generally students knew the expected results from prior reading or from pre-laboratory discussions led by their teachers. Subsequently the students felt no need to treat their observational data as viable unless it resembled expected patterns. Conflicting and contradictory data were ignored rather than explored. Here, the authority of the textbook or teacher ruled. There was no need to consider alternative explanations or to review their procedures; the book must be right and their results must be wrong. Do teachers really want to encourage such uncritical learning?

One of the contributing factors students gave for trusting textbook predictions rather than their own data was their lack of confidence in their laboratory techniques or even the inferior apparatus from which they would supposedly produce precise and reliable data. These apparent limitations justified their behaviour of excluding anomalous results. Anomalies were simply omitted rather than repeating the procedure or offering an explanation for the experimental variation. As long as the students thought they understood what was supposed to happen it was considered acceptable practice to ignore results which did not fit expectations. Exercising common sense was seen to be an acceptable alternative to checking the viability of unexpected results.

While the practices of copying results, modifying data to fit textbook predictions, and the unjustified exclusion of anomalous results are clearly undesirable behaviours to foster in science, fabrication or theft of results was the most serious type of fudging we identified. Only a few of the students admitted to the practice of making up results in lieu of actually carrying out the experiment. Fortunately, most of the others expressed disdain for this fraudulent behaviour. Nevertheless, they acknowledged it was a reasonably common phenomenon which, like the other types of fudging, students invoked in response to certain constraints and actions over which their teachers had control. Even though their teachers did not directly condone fudging, their actions and procedural routines fostered rather than discouraged the practice.

What is wrong with fudging?

Sufficient recent television *exposes* have highlighted the contempt with which the general public views fraudulent practice in business and industry. So in many ways the answer to this question is obvious; fraud is wrong and is both immoral and illegal. But as we have argued, students engage in different levels of fudging. Are the 'minor forms' of fudging, like the unjustified exclusion of anomalous results, to be viewed in the same light as 'white lies' or should all forms be discouraged? While we don't wish to be perceived as Ivory Tower morals campaigners, we believe that all forms of laboratory fudging should be discouraged. There are two major reasons for our position.

From a constructivist perspective of learning, emphasis is placed on the viability of knowledge rather than establishing the 'absolute truth' (e.g., von Glasersfeld, 1993). This entails some sort of testing whether specific knowledge is useful in enabling an individual to attain particular goals. If the knowledge is found to be robust in a range of contexts, it will be regarded as viable; it is viable if it works. When teachers encourage students to determine the viability of their knowledge they empower students to take personal responsibility for their learning. In contrast, when students are disempowered they depend solely on external criteria to test the viability of knowledge claims. Reliance on a text book or the teacher as the final authority for knowledge claims diminishes an individual's control over, and intrinsic motivation for, learning and creates a climate in which fudging is practised.

The second reason why fudging should be discouraged is that this practice contradicts the sort of attitudes and behaviours considered desirable in school science programs (e.g., Australian Education Council, 1994; Hodson, 1993). In *A National Statement on Science for Australian Schools* (Australian Education Council, 1994, p. 5), for example, a stated expectation is that school science curricula should develop students' ability to:

> Uphold attitudes and values such as openness to new ideas, **intellectual honesty**, commitment to scientific reasoning and to striving for objectivity, **respect for evidence and for the tenacious pursuit of evidence** to confirm or challenge current interpretations (emphases added).

This goal has already been embraced by recent syllabus innovations. In Queensland, for example, the *Physics Senior Syllabus* (Board of Senior Secondary School Studies, 1995) has listed open-mindedness, respect for evidence and honesty as required outcomes of the general objective: "to develop attitudes and values" (p. 4). If teachers are to pay more than lip service to syllabus requirements, they can no longer turn a blind eye to student fudging.

How can students be dissuaded from fudging?

This question can be answered by examining the reasons why students feel the need to cheat. The major reasons students have given us to rationalise their fudging behaviour include: time limitations to complete lab tasks, lab assessment practices whereby only 'correct' (as judged by external criteria) results are rewarded, poor techniques and inadequate apparatus make it impossible to achieve reliable results.

If teachers reduced the number of cookbook labs to be 'covered' there would be more time for students to do a better job; they would feel less pressure to fudge. They could now take more care in collecting data and even repeat procedures where necessary. Some of these labs could even be used for different purposes. Selected labs could focus on the development or fine tuning of particular lab skills (e.g., titration), while others might be used as stimuli for subsequent student designed investigations. These open-ended investigations provide the greatest potential for student learning. Here, students are more likely to experience scientifically authentic learning contexts. Not only would they have sufficient time to repeat procedures until obtaining a reliable set of data, but also they could follow alternative pathways and test the viability of their knowledge (see Roth, 1994, 1995).

Some students in our studies claimed that they felt no need to fudge, as they did not receive marks for 'correct' lab reports. Instead, their teachers valued discussions arising from anomalous results and very few lab reports were submitted for assessment. The lab report is perhaps the most over-used genre in school science (see Ritchie, 1992). While the scientific community do report their findings formally in the form of a scientific paper, they don't write one every week. When scientists do submit a paper, it is on a topic that they themselves have posed and investigated. So, the practice of submitting weekly lab reports and having them marked on the basis of 'correct' results lacks authenticity and appears to encourage fraudulent practice. It would seem more sensible to us to replace many of the traditional lab reports with a reflective journal, diary or 'learning log' (Cohen, 1990). This technique allows students to engage in a personal dialogue with their teacher. It also encourages students to self-monitor, ask questions and jot down thoughts, and serves as a vehicle for producing ideas about their observations. In a sense, this log would better reflect the dynamic nature of authentic scientific research.

Inferior laboratory apparatus prevalent in so many schools is another contributing factor to fudging behaviour. Students in our laboratory studies had access to sophisticated apparatus that only university budgets can afford. In contrast, schools rely on less expensive models or poor substitutes. It seems almost incredible, then, that some teachers would expect their students to produce precise results from cheap equipment. By reducing the number of lab exercises and increasing the quality of apparatus available, students are less likely to become frustrated and tempted to engage in fraudulent practice. Relatively inexpensive laboratory interface probes can be substituted for primitive and imprecise apparatus as well as provide ideal sets of data with which students can work. Numerous probes are now on the market and few schools are without PCs. A cost sharing scheme within a network of local high schools could increase access to a range of such devices while minimising costs to individual schools.

While some laboratory techniques are required in a series of lab exercises, many are used for a single lab. This means that students regularly experience new techniques without developing mastery. Better sequencing of laboratory exercises (i.e., linking activities by considering the required skills rather than relying on conceptual development alone) might facilitate skill development. When students provide 'perfect' results with each new technique why don't their teachers express amazement? That students continue to submit near perfect results under these circumstances, without their teachers expressing a degree of suspicion, can only reinforce students' fraudulent practice. In this way teachers promote rule-governed student behaviour where the emphasis is on following procedures and obtaining the right answer. It is only when students engage in activities (like open-ended inquiry) that allow them to contextualise their skills that they can progress towards expert behaviour (see, Benner, 1984; Dreyfus & Dreyfus, 1986). Perhaps reports related to labs which focus on skill development should not be assessed in the same way as other labs; thus emphasising mastery of technique rather than the outcomes.

Conclusion

From discussions with students involved in our series of studies of open-ended research projects, it appears that the current emphasis on the quantity of cookbook laboratory exercises (e.g., Garnett, Garnett & Hackling, 1995) and the associated teacher practice of rewarding near perfect lab reports for assessment fosters fraudulent student practice. By setting unrealistic expectations and turning a blind eye to fudging, teachers signal that it is OK to cheat. So, far from being fictitious, our opening vignette illustrates that many current school labs are indeed sites for fraudulent practice. It is our belief that the inclusion of properly supervised open-ended research projects in the science curriculum would not only offer a potentially rewarding experience for students, but also a scientifically authentic context for learning. There is an increasing amount of literature (e.g., Roth, 1995) and practical advice (e.g., Woolnough, 1994) now available regarding the implementation of open-ended laboratories that teachers can access.

Students start out as novices in experimental science. They only progress beyond that stage when given the opportunity to contextualise their learning (cf., Benner, 1984; Dreyfus & Dreyfus, 1986). We propose that immersing students in a climate where fudging is widely practised prevents students from learning authentic science and so prevents them from progressing to the expert stage.

If intellectual honesty and the pursuit of viable knowledge are to be valued by teachers as realistic and desirable outcomes of school science, a change in emphasis in many classrooms is required. By disrupting the routine of submitting traditional lab reports, teachers are likely to place greater emphasis and value on more authentic scientific discourse. Here, discussion of discrepancies and anomalies might lead to the exploration of alternative solutions and the need for a refinement in techniques. As well, such discussion is likely to foster student reflective practices. In turn, student reflection is likely to facilitate construction and reconstruction of particular concepts.

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