A triggering strategy for improved pass rate in software-managed evaluations of Physics practicals for the Engineering Programmes at the University of Johannesburg

Leelakrishna Reddy, Padmanabhan Nair, Sam Ramaila and Jan Oelofse

Department of Applied Physics and Engineering Mathematics,

University of Johannesburg, Doornfontein Campus,

P.O. Box 17011, Doornfontein, 2028

Corresponding author: krishr@uj.ac.za

Abstract

The non-traditional approach to the evaluation of Physics practicals through an innovative software embedded system, first of its kind in South Africa, allows students to execute and report the results of an experiment independently. This system evaluates the individual performance in an experiment in terms of accuracy, analysis of data and report of the necessary results obtained. As part of the evaluation of the experimental report, the students' data is loaded into a software system and checked against the pre-loaded data for the particular experimental set-up and equipment. Thus, students are unaware of the exact requirements for securing marks at each step and process of the report. To overcome this difficulty, the experimental group of students are given support through rigorous tutorials and consultations in contrast with a control group of students. Results reveal that in relation to the control group, a good correlation exists between good marks attained through such support system in comparison to the control group. This has become a valuable outcome in view of the fact that Physics practicals carry a full modular credit in the diploma programmes of Engineering Faculty at the Doornfontein Campus of the University of Johannesburg.

Key words: experimental skills, strategy, practicals, engagement and mentorship

Introduction

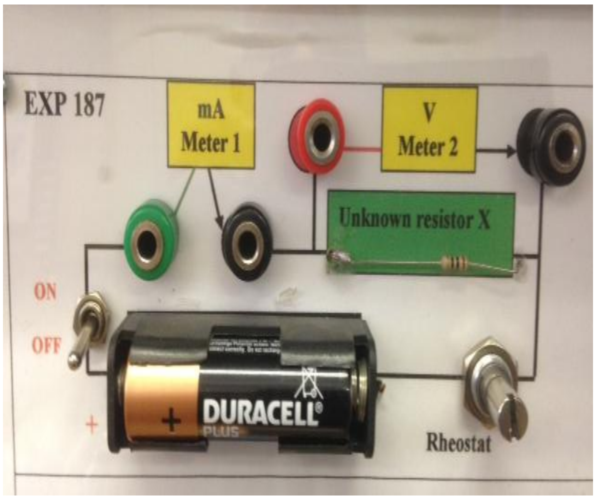
It has been noticed that the first-time entering students in the Diploma programmes of the University of Johannesburg, lack the basic experimental skills needed in Physics (such as observations and manipulation of equipment) and communication skills (such as reporting of observations and results) [1]. Although they may be pockets of excellence in good practices of such skills in the elite schools, the underdevelopment of these skills is most prevalent in many under-resourced public schools. These students come to tertiary institutions with an inherent fear for practical work. Fortunately, the Department of Applied Physics and Engineering Mathematics (APEM) of the University of Johannesburg has come to the rescue of this vast majority of students that are under-prepared for practical work. The students doing Physics as a service module for the Engineering Faculty are introduced to a whole array of fundamental practicals in Physics which are uniquely designed to be student-friendly and interactive. Contrary to the traditional approach to conductance and assessment of practical work, the APEM department has developed a software embedded rubric marking system that is linked to the background data of every one of the 350 practicals that is housed in 7 laboratories. In order for the student to do meaningful practical work the student has to “interact with the materials”, collect data, analyse it and “make sense of the natural world” [2]. Such an innovative assessment marking system has many parameters which the student is not accustomed to and they need to be made aware on a regular basis. The aim of this article is to provide a triggering strategy in the form of support and controlled mentorship through engagement with a spin-off benefit of demystifying the fear of practical work, enhancing laboratory skills and for improved throughputs.

Methodology and discussion

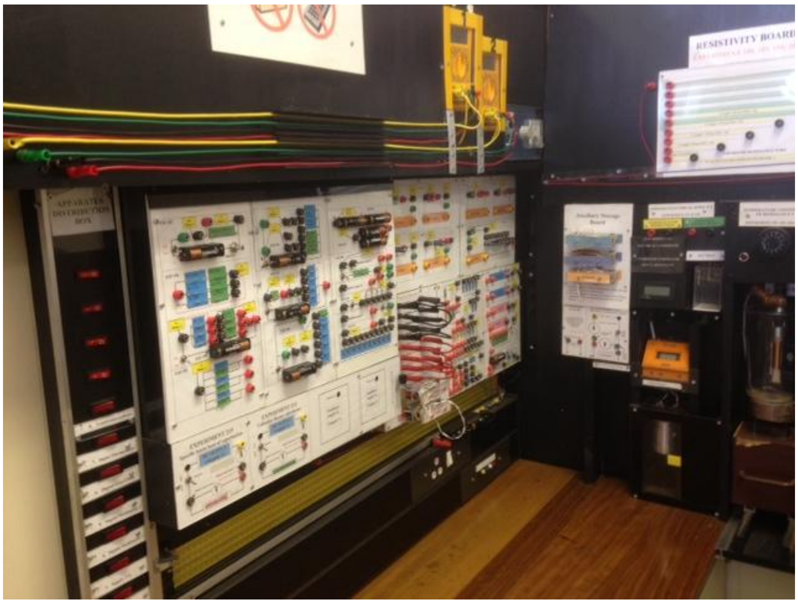
The students in the Electrical Engineering as well as the Chemical Engineering Diploma groups have been targeted for implementation of the engaged triggering strategy mechanism. For the Electrical Engineering group a total of 178 students were sub-divided equally and randomly among 4 members of staff with each staff having 2 groups of students. It must be mentioned that the admission criteria for this group of student is not as stringent as for the Chemical Engineering group. These groups of students are accordingly allocated labels A1, A2, B1, B2, C1, C2, D1 and D2 and each group has to perform a total of 17 practicals for the semester. The group of students D1 and D2 are regarded as the experimental group due to the specific implementation of the engaged monitoring strategy and the other groups A1 to C2 were called the control groups.

At the beginning of the year each student has to purchase a Laboratory Manual and a Laboratory Result Book [3]. The Laboratory Manual contains extensive theories, methods and the procedures about undertaking to do any of the practicals, while the Result Book is for data collection, calculation of unknown parameters, drawing of the necessary graphs and for the submission of the final report. At the beginning of each practical session, the students are briefed on the practicals that they have to perform; they then perform the practicals individually as each student is allocated one of 24 cubicles according to class register order. A typical laboratory cubicle and a typical excerpt from the Result Book are shown as pictures 1 and 2 below. Once the experiment has been performed, the students are given an open opportunity to discuss the principles and theories relevant to the practical work undertaken. A typical outcome of an exemplar data is discussed.

In terms of the marking memorandum of say, EXPERIMENT 187 (shown in figure 1), the pitfalls and expectations of the excel rubric marking programme (ERMP) are fully explained. The students are then given a few days to do the necessary calculations, graphs and results write-up and once they are satisfied, they will have to first pass it over to the lecturer for scrutiny before final submission. This can be regarded as a "forced one-to-one consultation" with a strict register kept for defaulters. Once clearance is given by the lecturer after further changes have been implemented, the student then submits the results to the data capturer for assessment. Within a few days the results are released on the notice board for all to see. At the onset of the next practical, a post-mortem is done on the previous work together with the defaulters of regular consultations. Consultations for these students were open the whole day for the duration of the practical write-up, even in the corridors and even few minutes before lectures. Once the students knew the pitfalls of the marking system, the rules became slightly relaxed.



Picture 1: Picture 1 shows the laboratory layout for one of these experimental investigations.



Picture 2: A typical laboratory layout

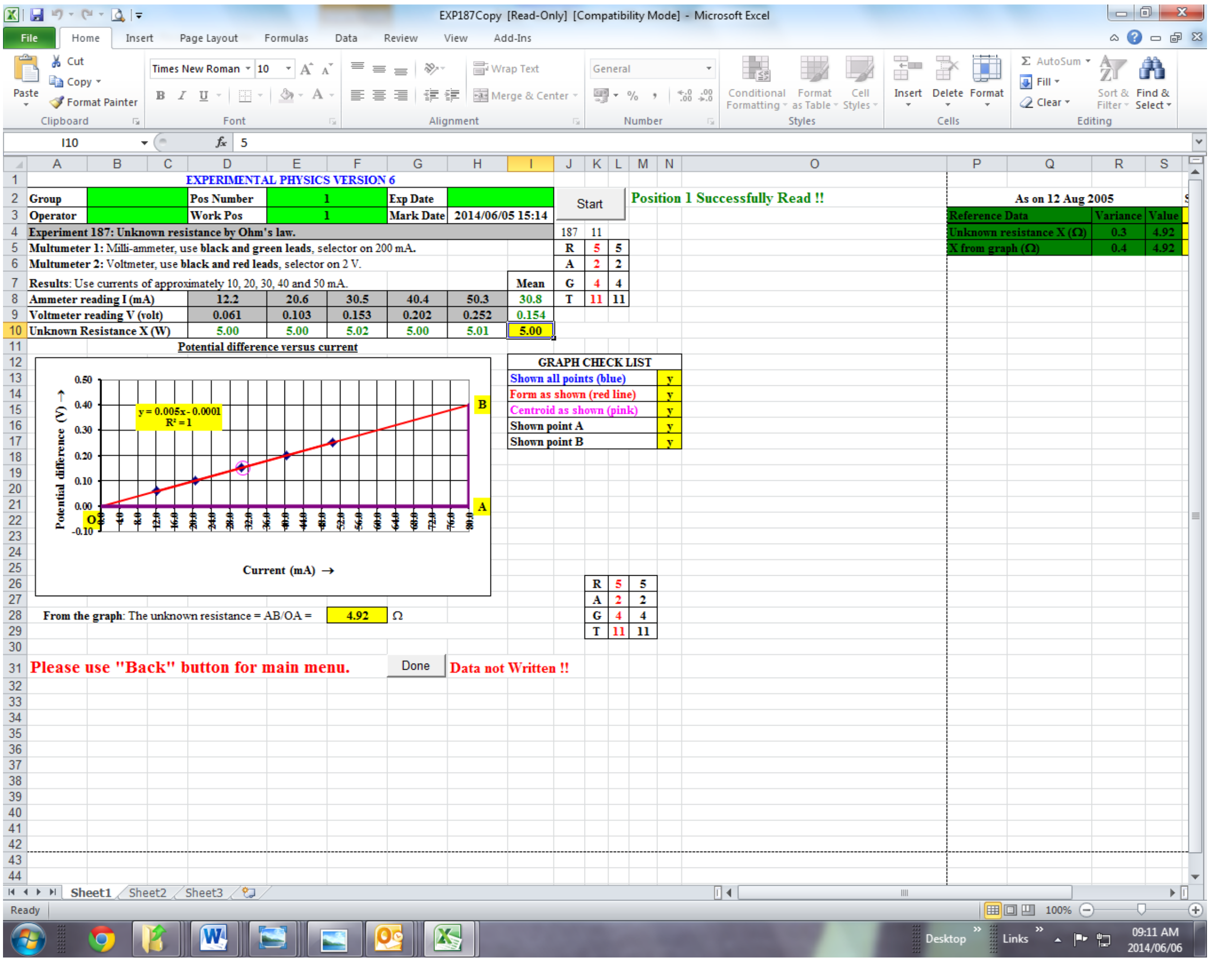


Figure 1: A typical layout of a laboratory report.

The impact of such an intervention can be seen from progression of the students' marks. An analysis of the marks of 6 such experiments numbered EXP 187-190 and 193-194 from the various groups A1 to D2 is shown in Table 1 for comparison. The table shows the class average percentage that was obtained by each group.

Table 1

	Group allocation						
Experiment number		187	188	189	190	193	194
Control group	A1	65%	84%	81%	40%	73%	33%
	A2	72%	85%	79%	61%	81%	74%
	B1	76%	83%	78%	51%	83%	54%
	B2	Did not do these experiments					
	C1	79%	85%	78%	67%	88%	59%
	C2	79%	85%	78%	67%	88%	59%
Average		**75%**	**85%**	**80%**	**57%**	**80%**	**58%**
Experimental group	D1	85%	88%	83%	66%	75%	72%
	D2	79%	85%	78%	67%	88%	59%
Average		**86%**	**94%**	**89%**	**76%**	**86%**	**74%**
Shift in % mark		+11%	+9%	+9%	+19%	+6%	+16%

Percentage shifts of 16% and 19% clearly indicate the positive spin-off benefits of an engaged strategic intervention programme and which could be prescribed for other groups as well. A comparison of the overall performance of the students among the various groups that have done the prescribed numbers of practicals for the semester 1 is shown in Table 2 below.

Table 2

	Control group						Experimental group	
Groups	A1	A2	B1	B2	C1	C2	D1	D2
Overall percentage	66%	70%	68%	67%	65%	65%	76%	79%
							Average = D1 + D2 = 78%	
Shift in % marks	**-12%**	**-8%**	**-10%**	**-11%**	**-13%**	**-13%**		

The experimental group has performed on average about 11% better than the control groups. None of the groups were at par with the experimental group and thus the justification of the implementation of the strategic intervention programme. One must also bear in mind that these groups of students were randomly distributed among the lecturers concerned. All these comes at a cost of premium time of a lecturer who has to strike a balance between research and teaching time. However, the rewards of such a programme are enlightening as these students have had a minimum exposure to practical work at schools. This is in confirmation with the latest press release that South African learners are placed bottom of the class in mathematics and science education globally [4]. This is compounded by the fact, through a survey (n = 222) done just at the start of the semester that roughly 50% of the students have had no exposure to praticals at school whatsoever.

On the other hand, the Chemical Engineering group which has a cohort of 102 students has been also divided among 4 members of staff. The admission criteria for this cohort are capped at a higher level than the Electrical Engineering group and thus there is a higher expectation from them. Out of these 4 groups of students one group (E) has been designated as the experimental group and for which the strategic intervention programme has been implemented. The results, which show the cumulative effect of 34 practicals, are summarised in Table 3 which points to an interesting departure from the norm.

Table 3

GROUPS	E	F	G	H
CLASSIFICATION GROUP	EXPERIMENTAL GROUP	CONTROL GROUP		
AVERAGE RESULTS	70%	65%	75%	76%

The results are very interesting, in that one group performed 5% worse while 2 groups performed about 7% better than the experimental group. The mitigating factors attributed to this performance could be:

(a) Better exposure to practicals

(b) Being taught by the same lecturer for the theory

(c) Taught by a more experienced person.

Conclusion

The implementation of the strategic intervention programme has proved anecdotally that the engaged mentoring system works for the development of conceptual understanding that keeps the student focussed and as well as it develops the necessary skills that are an embodiment of higher learning. Acquiring such skills will allow them to proceed into the second semester with a reservoir of process skills and positive attitudes that will challenge them at different levels of inquiry through best practices learnt in science laboratories.

References

[1]. www.examfear.com/files/00/45/2010-12-09-20-08-05.pdf, retrieved 30/5/2014.

[2]. Lunetta et al, 2007, Attitudes and perceptions related to practical work.

[3]. A. Kotze, Experimental Physics, Method and Theory.

[4]. http://www.news24.com/SouthAfricaSA-has-worst-maths-science-education-education-in-world-20140602.

.