LabRAT – An electronic mark recording system for large laboratory classes

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Abstract: *An electronic laboratory marking system was recently developed and introduced into the junior physics teaching laboratory. The system allows tutors to enter marks into a central database directly using handheld PDA (Personal Digital Assistant) computers. The system has greatly reduced the administrative load in handling laboratory marks, but has also enhanced the student's experience of the laboratory. After the laboratory class has finished, students are able to check their marks online through a web page. The students now regularly track their progress through the laboratory and can query potential recording errors as they arise. The system enhances the idea of continuous assessment, by giving up-to-date feedback to over 800 students who pass through the laboratory each week.*

Introduction

The School of Physics has a large cohort of junior (1st year) physics students, with more than 800 students passing through the teaching laboratory each week. The stated objectives include gaining experience with laboratory equipment, learning how to conduct experiments, and learning to record and report their results. However the laboratory component of a student's course also provides a solid base of marks on which to build a good overall result. It is, of course, an assessment exercise and assessment is integral to guiding student learning and defining curriculum. 'What and how students learn depends to a major extent on how they think they will be assessed' (Biggs 1999). The importance of assessment was recognized in a large scale study of assessment in Australian universities undertaken in 2001-2 (James, McInnes and Devlin 2002; James and McInnis 2001).

Any learning task should be *developmental* for the students. If it is an assessment task it is necessarily also *judgmental*. There is an inevitable tension between these two requirements that must be decided in designing the activities and assessment. The aim is to maximise student learning outcomes by constructively aligning assessment tasks to learning objectives (Biggs 1996). In the laboratory situation, it is the tutors who need to ensure the alignment has a chance of working. Even the best laboratory courses will stand or fall as a result of the ability and attitudes of the tutors.

The junior physics laboratories set out to minimise the obtrusiveness of assessment and establish the tutors as helpers rather than judges. There is no 'marking' where students are awarded marks based on the perceived relative 'value' of their work. A mastery system is used, where students work in teams of three and are awarded a 'checkpoint' when they pass each specific stage in the laboratory class. On reaching a 'checkpoint' the students will summon a tutor to check that their work is satisfactorily recorded in their logbook. If the work is acceptable, then each student present in the group receives a checkpoint, and hence the mark associated with it. Typically, each laboratory class has four marks – three for laboratory work performed during the class and one for satisfactorily attempting the 'pre-work' (usually a couple of questions designed to make the students think about the experiment before entering the laboratory). Two written tests are also held each semester during the laboratory class with numerical marks awarded to each student individually.

This assessment scheme has been in use for over a decade and leads to a positive working atmosphere between tutors and students. Conscientious student groups usually receive full marks and, although not every member of a successful team will pull their weight, the less committed individuals usually lack a full complement of pre-work marks and/or do poorly in the laboratory-based skills test.

Mark recording

Checkpoints are awarded during the laboratory class, rather than after the event. In the past, marks were recorded on paper and a total entered into a mark sheet at the end of the class. The mark sheets were subsequently entered into a spreadsheet by hand. The process of entering marks twice was both time consuming and error prone. In addition, while students were free to check their marks on the mark sheet during laboratory classes, few did so during the semester. At the end of the semester the laboratory marks were posted on a large noticeboard and also on an internal web page. Students would suddenly take a keen interest in their marks, leading to a flood of requests to rectify genuine recording errors, as well as enquiries from opportunists making more dubious claims.

The *LabRAT* electronic marking system eliminates paper from the marking process completely and allows checkpoints to be recorded as they are awarded during the laboratory session. Laboratory tutors are equipped with handheld PDA (Personal Digital Assistant) computers with which they enter student's marks into a central database in real time. By eliminating any further data entry, the scheme saves a great deal of staff time, estimated at one full working week per semester. Further, the electronic marking scheme is more accurate as the only opportunity for human error is during mark entry in the laboratory class. Finally, the scheme provides a real-time summary of marks accessible at any time through the Web, encouraging students to track their results and take a more active interest in their own progress.

The *LabRAT* electronic marking system

This electronic marking system is composed of standard hardware, while the software components have been developed using open source tools wherever possible. The handheld PDA computers connect to a server via a wireless local area network (802.11 WLAN) providing realtime data exchange (a schematic of the architecture is shown in Figure 1). A .NET compact framework application running on the handheld PDA provides a simple user friendly front-end to the database server. A back-end application written using the *Ruby-on-Rails* framework provides a web-services interface to the PDA, as well as a conventional web-browser interface for reviewing student data and database maintenance.

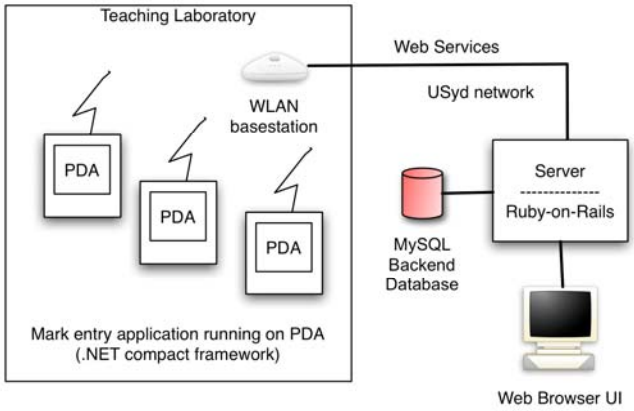

Figure 1. Schematic of the computer architecture, showing handheld PDAs connecting wirelessly to the backend server, database & client administration computers

An *Apple XServe* computer was used to run both the *MySQL* server and *Ruby on Rails* application. 18 HP iPAQ rx1950 PDAs were purchased at a cost of AU$369 each, together with four Linksys WAP54G wireless base-stations to cover four teaching laboratories, at a cost of AU$135 each. Each base-station reliably covered a 200 square metre laboratory, filled with students, benches and experimental apparatus. For security purposes the base-stations were setup only to communicate to

the PDA computers purchased, via their unique *Media Access Control (MAC)* address that is unique to each PDA. The database is backed up every evening to tape, as part of the School of Physics' centralised backup policy. The battery life of a fully charged rx1950 PDA is roughly five hours and is more than sufficient for a three hour laboratory session. The PDAs are issued in protective pouches (supplied with the PDA unit) and usually worn on a cord round the neck. System reliability has been good, with up to eight PDAs working simultaneously across two concurrent laboratory classes. Only one accidental breakage was suffered in 1800 hours of use during the first semester of 2006.

Operation and evaluation

At the beginning of a semester, *LabRAT* is configured with the laboratory sessions, classes and assessments. Multiple courses can be configured with simultaneous classes and sessions. All configuration takes place using an administrator account via a standard web-interface. Assessments can be numerical or boolean (checkpoints) and are unlimited in number, although the PDA screen typically allows only four assessment points to be shown at any one time.

Student lists are imported from university enrolment system shortly before the beginning of semester. As the students usually work in teams of three, *LabRAT* offers a simple method for recording the identity of team members. In the first laboratory session, students use a highly restricted *LabRAT* web-page to enter their Student Identity number (SID) into *LabRAT* where it is cross-checked with the previously imported class list and the student group is then created in the database. The laboratory supervisor can change the team grouping dynamically throughout the semester, allowing students to join a team, change team, join or drop out of the course.

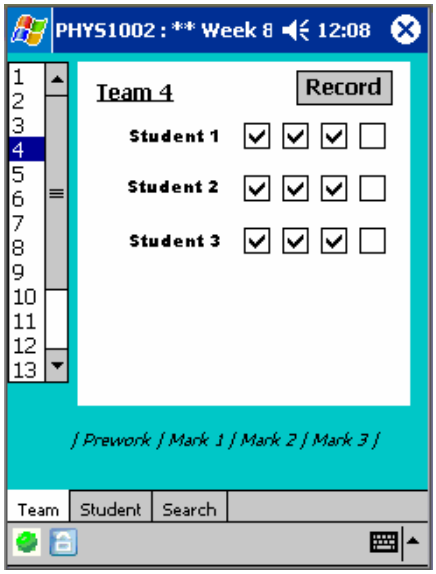

Figure 2. *LabRAT* running on a PocketPC PDA. Marks are entered by tapping the screen with a stylus.

At the beginning of a session, a tutor logs into *LabRAT* using their individual PDA. The marking interface on the PDA is simple and shown in Figure 2. Choosing the team number on the left hand menu brings up a list of students in that team and their marks awarded that session. In most cases checkpoints are awarded, as shown in the example, although numerical entry is also possible. In the event of students catching up missed laboratory classes by joining another session, it is also possible to locate a student using their SID. Each mark is logged with a timestamp and the identity of the tutor who made the award. This assists in resolving student complaints over marking, but also allows the attendance and activity of tutors to be monitored. A supervisor or administrator can alter or award marks retrospectively if necessary. In fact, a configurable permissions system exists that can be used to give certain classes of user the power to amend records, add students etc.

Summaries of marks can be generated on any desktop computer via the web interface. The example shown in Figure 3 shows a class at the end of the semester, indicating the checkpoints and numerical entries. Statistical analysis can be performed on numerical marks, providing mean and standard deviation within each laboratory class, as well as the course as a whole. In addition, the data can be exported for use in a spreadsheet.

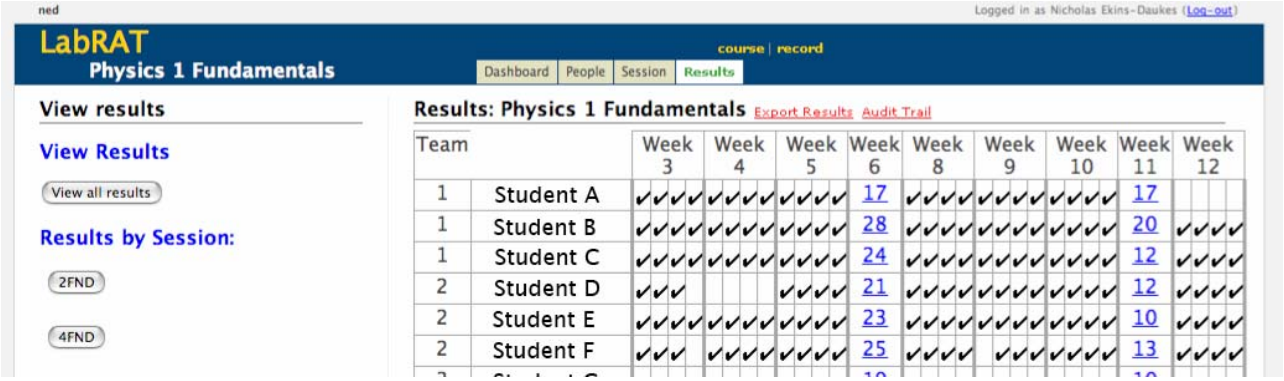

Figure 3. Student mark summary viewed using a web-browser, showing check points and numerical test results

LabRAT was introduced into the junior physics teaching laboratories in March 2006 and the response has been positive. Analysis of the web-server log showed that all students checked their marks at least once, with the average student checking their marks four times over the semester; the most enthusiastic checking their marks 42 times over twelve weeks. Figure 4 shows the number of students checking their marks each day over the semester. The peak observed around the 20th May correlates with the release of progressive test marks. The peak in the first week of April does not correspond to any particular assessment and is therefore attributed to initial enthusiasm for checking marks online. Indeed, students have praised this facility for checking marks in student-staff liaison meetings. Tutors too have responded positively, as they can approach a student group with the PDA displaying the student's names and checkpoints awarded in that session. This helps break down the inevitable formality of a large laboratory class and helps tutors operate more effectively.

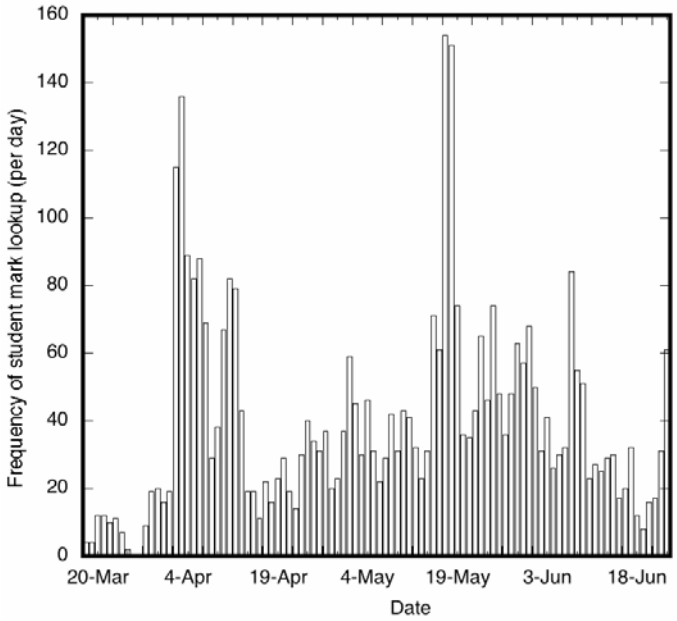

Figure 4. Frequency with which students check their laboratory marks online

Summary

LabRAT reduces the administrative load in operating an assessment system intended to minimise the impact of marking on student learning. It encourages students to be active in monitoring their progress in the laboratory component of their course. The initial hardware and development costs will be recouped over time in savings on data entry. Finally, in an environment where keeping laboratory equipment up-to-date is costly and difficult, it leaves the students with a favourable view of the School of Physics.

References

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