The tutorial benefits of on-line assignments: *MasteringPhysics* in first year physics at the University of Sydney

John O'Byrne and **Richard Thompson**, School of Physics, The University of Sydney
j.obyrne@physics.usyd.edu.au r.thompson@physics.usyd.edu.au

Introduction

'Assessment in higher education has two competing goals: *developmental and judgmental*' (Brown, Bull and Pendlebury 1997). On the one hand there is the need to encourage learning, but there is also the need to assess for understanding and competency.

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 is widely recognised, for example in a recent large-scale study of assessment in Australian universities (James, McInnis and Devlin 2002, James and McInnis 2001).

Regular assignments are employed in first year physics at the University of Sydney for both developmental and judgmental purposes. In recent years, assignments have been paper-based collections of four questions, submitted in small groups to encourage group learning. The questions are a mix of short answer and numerical, problem-based questions. The aim is to test understanding of concepts and relationships, not merely problem solving ability and memory. This assessment is intended to reward a deep approach to learning – i.e., 'learning the facts *in relation to* the concepts' rather than 'learning *just* the unrelated facts (or procedures)' (Ramsden 1992). Goals like these are widely espoused, however studies such as Lindblom-Ylanne and Lonka (2001) often find that assessments actually guide students towards superficial learning.

In Table 1 we rate our paper-based assignments relative to a list of conditions believed to promote student learning (Brown, Gibbs and Glover 2003). It can be seen that the major downfall we perceive is in timely, effective feedback to the students. Entwistle, Hounsell, Macaulay, Situnayake and Tait (1989) found that an important contributing cause of failure of first year students is an absence of feedback on progress. The on-line system on which we report here addresses this problem.

Table 1. Staff ratings of the effectiveness of paper-based assignments in promoting student learning.

How well do the assignments generate good quality learning activity?		
Assignments …		***Rating / Comment***
1	capture sufficient student time and effort	√ *provided they don't simply share answers*
2	distribute student effort evenly across topics and weeks	√ *assignments every 2 weeks*
3	engage students in productive learning activity	√ *short-answer and problem-based questions*
4	communicate clear and high expectations to students	**√?** *experience with exam-style questions*
How well does feedback on assignments support learning?		
Feedback is …		
5	sufficient, often enough and in enough detail	**X** *often minimal, but also a sample solution*
6	provided quickly enough to be useful to students	**X** *~2 weeks later when next assignment is due*
7	focused on learning rather than on marks or students	**X** *minimal personalised feedback*
8	linked to the purpose of the assignment and to criteria	√ *sample solution does provide a good guide*
9	understandable to students, given their sophistication	***X*** *personalised feedback often brief and cryptic*
10	received by students and attended to	**X** *too late to be useful until studying for exams*
11	acted upon by students to improve their work or their learning	**X?** *often too late to help with next assignment*

What is *MasteringPhysics*?

In recent years, textbook publishers have offered a variety of CD or web-based materials to accompany their physics texts. In physics at the University of Sydney we have been reluctant to integrate electronic materials into our teaching because it is a big step when the benefit to students is uncertain. We have also been concerned about adding to student workload and imposing technological and access 'barriers' between students and the material.

In July 2003 Pearson/Addison Wesley, publisher of our main first year physics textbook (*University Physics* by Young and Freedman, 11th edition), released the *MasteringPhysics* on-line tutoring and homework system. *MasteringPhysics* is an adaption of the *CyberTutor* system from MIT (Morote and Pritchard 2002) (Further papers related to *MasteringPhysics/CyberTutor* are available from the MIT group at http://relate.mit.edu/publications.html). Other sophisticated systems to assess complex physics problems are also under development (e.g., see Liew, Shapiro and Smith 2004).

MasteringPhysics is accessed by students through the web (http://www.masteringphysics.com). It provides questions that use a Socratic dialogue with the student - when they have difficulty in answering a problem it offers hints or a simpler problem, provides tailored feedback to a wrong answer and ultimately rewards the student's method and not just the final answer.

MasteringPhysics offers a variety of advantages over the paper-based assignment system:

- Feedback is immediate, allowing a diligent student to reach the correct answer for each question. Under the recommended procedures that we adopted, student mark is determined by the number of incorrect answers submitted and hints used ().
- Marking is immediate, relieving the staff of this task and immediately reporting marks for each question to staff and the student. A diligent student should get 100% (or more!).
- All students must complete the assignment under their own login, which promises to substantially reduce copying of assignments and allows us to increase the value of assignments.

The trial at the University of Sydney

The *MasteringPhysics* system was trialled at the University of Sydney during second semester of 2004 in the PHYS 1003 (Technological) unit of study. This group of approximately 250 students, mostly from science and engineering degrees, was chosen because problem solving is an important aspect of their course. Importantly, these students had already completed one semester of physics using the paper-based assignment system. They could therefore comment on the relative merits of the two systems from the students' perspective.

The system was used for six assignments that covered the subject areas of fluids, electromagnetism and quantum physics. Each assignment consisted of eight questions - two five and two ten mark 'assignment' questions, reflecting the structure of the paper-based assignments, plus four 'tutorial' questions worth just two marks each. These were intended to encourage use of other tutorial questions provided separately.

To monitor the implementation of the system a small grant was obtained from the University's SciFER (Science Faculty Education Research) grant scheme to fund a part-time research assistant (Thompson), independent of the teaching staff of the unit of study. The aim of this project was to study the effect of *MasteringPhysics* on student attitudes and results, in particular in comparison to the alternative paper-based assignment system. Feedback was obtained from students collectively using a survey and focus groups, and individually via the *MasteringPhysics* website or *WebCT*-based discussion forum. In addition, marks and participation rates were monitored using the *MasteringPhysics* system and other assessment tasks.

Issues arising from the trial

In general, students found the *MasteringPhysics* environment reliable and easy to use. However, a number of issues were raised or clarified by the focus groups and the survey.

- Lack of computer access was not a major issue. 95% of students had access to a computer at home, plus an internet connection (broadband 55%, dial-up 40%)
- Input of equations can be difficult for the novice user, however one goal of the trial was to make students aware of the strict syntax requirements when using computers in scientific applications.
- Students need to understand the value of using hints - sacrificing the small bonus of not using them for the larger reward of getting the problem correct!
- Technical problems were remarkably few. Errors or omissions in questions were few and minor and fed back to the system administrators.
- Copying is minimised but still possible using *MasteringPhysics*. Students in the focus groups were not overly concerned because they realised that short term benefits of copying would be compensated by the reduced tutorial value of the system.

Survey results

Among the survey questions, students were asked several questions about the value of *MasteringPhysics* for them. These included:

- Did *MasteringPhysics* help you in *problem solving* in physics this semester?
- Did *MasteringPhysics* help your *understanding of concepts* in physics this semester?

Three staff members rated each response to these questions on an integral scale from -2 up to +2, corresponding to 'significantly negative', 'negative', 'neutral', 'positive' and 'significantly positive'. A combined rating was obtained by rounding the average of the three numerical ratings to the nearest integer. In general, the ratings agreed extremely well. The outcomes from the analysis, shown in Table 2, shows that the overall response to *MasteringPhysics* is clearly positive. It is interesting to note that the students rated *MasteringPhysics* slightly higher in helping them understand concepts in physics than in helping them with problem solving. This was unexpected.

Table 2. Student ratings of the helpfulness of *MasteringPhysics* in *problem solving* in physics and *understanding of concepts* in physics

	***MasteringPhysics* did not help**			***MasteringPhysics* helped**	
	significantly negative	negative	neutral	positive	significantly positive
Problem solving	8%	18%	3%	55%	16%
Understanding of concepts	3%	16%	2%	67%	12%

We looked for a relationship between the opinion of students about *MasteringPhysics* and their final overall results for the unit of study. Student responses were divided into two groups according to their rating of the value of the *MasteringPhysics* system for understanding of concepts in physics.

As seen in Figure 1, the mean final mark obtained by the group who thought *MasteringPhysics* helped their *understanding of concepts* in physics is slightly higher than for those who thought it did not. The number of students in Figure 1(b) is much smaller and a simple t-test yields a p-value = 0.13 that suggests there is little likelihood of a significant difference between the distributions. Any difference may reflect slight differences in the attitudes or backgrounds of the two groups. Factors such as gender have been examined but the data do not allow any statistically significant conclusions. An analysis of the *problem solving* comments yielded very similar results.

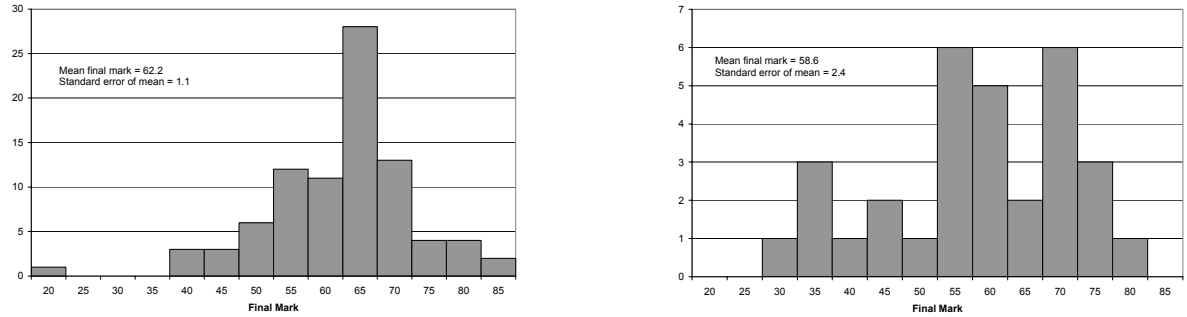

Figure 1. Final overall results in the unit of study for students who thought *MasteringPhysics* (a) helped and (b) did not help their *understanding of concepts* of physics.

Students were asked at the focus group meetings and in the survey to compare *MasteringPhysics* with the paper-based assignments. Comments were varied, ranging from

'Yes, I learnt more from this system than from the written assignments last semester.'

to

'No, [it] was a terrible system of learning. Hand written assignments are far superior.'

However, whatever they thought of *MasteringPhysics*, many of the students had no great love for the paper-based assignments.

MasteringPhysics as a predictor of examination performance

Proponents of *MasteringPhysics* claim it can be used to predict examination performance. Our data are presented in Figure 2, comparing the *MasteringPhysics* assignment mark versus examination mark for the students. Clearly this simple correlation is very poor (correlation R2 = 0.07). This is not surprising given the obvious tendency for students to achieve marks close to 100% on *MasteringPhysics* assignments. A more complex multi-variable correlation using factors such as numbers of correct responses, hints requested, etc. may be more successful. However a lack of good correlation between in-semester assessment and examination results is typical in our experience.

A further important conclusion is that the 2004 results are not significantly different from 2003 results. *MasteringPhysics* had no significant impact on student results in the examination.

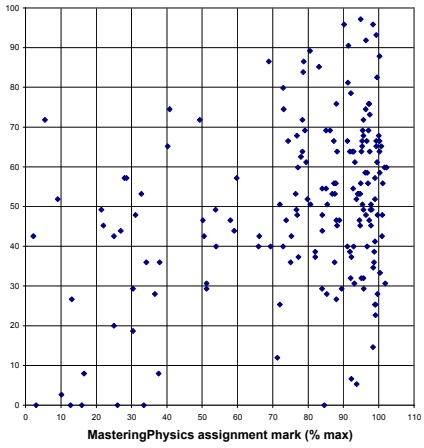

Figure 2. Comparison of *MasteringPhysics* assignment mark and Examination mark for the PHYS 1003 class in 2004

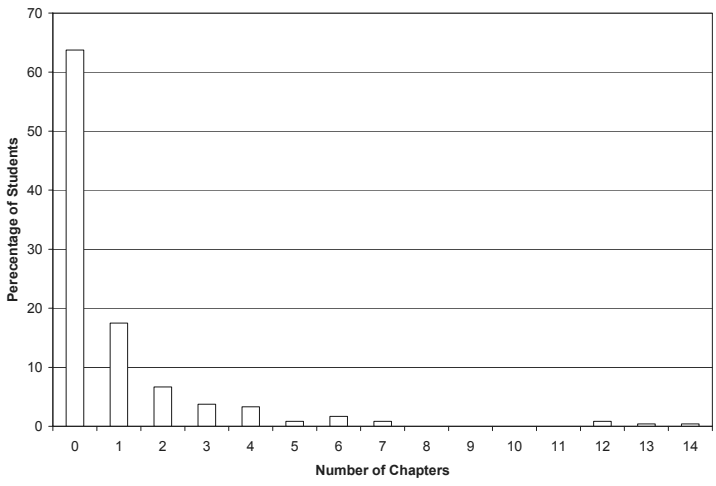

Figure 3. Percentage of students attempting some non-compulsory questions from book chapters covered by *MasteringPhysics*

Tutorial use of *MasteringPhysics*

It was hoped that the assignments, with their compulsory tutorial question component, would serve as a starting point for students to explore more questions in *MasteringPhysics*. The system kept a record of student use of these extra questions for the 14 book chapters covered in the unit.

As can be seen from Figure 3, use of this resource was very limited. Over 60% of students did not use them at all and almost no one used them systematically. For time-poor, assessment-driven students, perhaps this is not surprising. It simply reproduces previous experience where recommended but optional extra questions from the text book are rarely attempted by students.

Discussion

As described earlier, the attractions of *MasteringPhysics* as a teaching aid centred on its ability to deliver timely and targeted feedback to the students doing the assignments. The system of hints and the immediate feedback was generally popular with students:

> 'Yes, the feedback and hints assist you in the right direction and knowing that your answer is incorrect right away and getting a second chance is really, really good.'

From a technical point of view, *MasteringPhysics* performed well and most students adapted to it without many problems.

Table 3 illustrates our rating of the effectiveness of *MasteringPhysics* in the Trial against the same scale used for paper-based assignments in Table 1. Once again these are our perceptions, although in this case based on student feedback. Comparison with Table 1 emphasises our positive view of the effectiveness of *MasteringPhysics*.

Table 3. Staff ratings of the effectiveness of *MasteringPhysics* assignments in promoting student learning

How well do the assignments generate good quality learning activity?		
Assignments …		***Rating / Comment***
1	capture sufficient student time and effort	√ *provided they don't simply share answers*
2	distribute student effort evenly across topics and weeks	√ *assignments every 2 weeks*
3	engage students in productive learning activity	√**?** *but short answer questions lost*
4	communicate clear and high expectations to students	√**?** *but perceived loss of exam-style questions*
How well does feedback on assignments support learning?		
Feedback is …		
5	sufficient, often enough and in enough detail	√ *tailored to the student responses*
6	provided quickly enough to be useful to students	√ *provided when required*
7	focused on learning rather than on marks or students	√ *100% possible for many students*
8	linked to the purpose of the assignment and to criteria	√ *sample solution does provide a good guide*
9	understandable to students, given their sophistication	√ *tailored to the student responses*
10	received by students and attended to	√ *used to help answer problems*
11	acted upon by students to improve their work or their learning	√**?** *only used to complete the assignments*

There were losses in going from paper-based assignments to *MasteringPhysics*. Short answer questions cannot be marked by the system. Group work that our paper-based assignments encourage (in principle) is perhaps discouraged (also in principle) by students working through the *MasteringPhysics* questions under their own login name. Students particularly noted the loss of the close alignment between questions in the paper-based assignments and those in the final examination. The 'Skill Builder' questions used in *MasteringPhysics* are indeed different, but the other problems are conceptually similar to examination questions. However only the 'End of Chapter' questions, used for a few *MasteringPhysics* questions, are like examination questions in providing no feedback. Does this reflect an assessment-driven attitude where the students use the feedback simply to complete the assignment questions and don't see assignment questions as learning?

An assessment-driven approach to learning is also suggested by the very low usage of optional tutorial questions. This is not a change however, since only a few students ever find the time to do extra questions. With most students doing some paid work alongside their university and social commitments, making time for anything beyond assessment tasks is always an issue. Usage of *MasteringPhysics* beyond the compulsory assignments may be easier to encourage if students use it from the start of their university physics career, as has happened in 2005.

Disappointingly, the adoption of *MasteringPhysics* did not make a perceptible change in the performance of students in the final examination, although this is hard to establish without using a standard examination. This lack of impact occurred despite *MasteringPhysics* offering students a clearly better educational approach than the previous paper-based assignments. We suggest that the students' assessment-driven approach to learning did not allow them to take real advantage of the system, in particular by using questions beyond the compulsory assignment. We need to use *MasteringPhysics* encourage a new attitude among the students. We need to sell it better and have attempted to do that in a wider implementation of the system in first semester 2005.

Acknowledgements
This research was supported by a University of Sydney, Faculty of Science SciFER (Science Faculty Education Research) grant that funds Richard Thompson's position. We would like to thank the lecturers and students in PHYS 1003 for their cooperation.

References

Biggs, J. (1999) *Teaching for Quality Learning at University*. Open University Press, Buckingham.

Brown, G., Bull, J. and Pendlebury, M. (1997) *Assessing Student Learning in Higher Education*. London, Routledge. Quoted in Lindblom-Ylanne and Lonka (2001).

Brown, E., Gibbs, G. and Glover, C. (2003) Evaluation tools for investigating the impact of assessment regimes on student learning. *Bioscience Education Electronic journal*, **2**, 2-5. [Online] Available: http://www.bioscience.heacademy.ac.uk/journal/vol2/beej-2-5.htm [2005, July 6].

Entwistle, N.J., Hounsell, C.J., Macaulay, C., Situnayake, G. and Tait, H. (1989) *The Performance of Electrical Engineers in Scottish Education*. Report to the Scottish Education Department, Centre for Research on Learning and Instruction Department of Education, Univ. Edinburgh.

James, R. and McInnis, C. (2001) *Strategically Re-positioning Student Assessment.* Discussion Paper, Centre for the Study of Higher Education, Melbourne. [Online] Available: http://www.cshe.unimelb.edu.au/downloads/Assess.pdf [2005, July 6].

James, R., McInnis, C. and Devlin, M. (2002) *Assessing Learning in Australian Universities*. Centre for the Study of Higher Education, Melbourne.

Liew, C.W., Shapiro, J.A. and Smith, D.E. (2004) *Assessing student performance in solving complex physics problems*. Conference on Intelligent Tutoring Systems, September 2004. [Online] Available: http://www.physics.rutgers.edu/~shapiro/tutor/its04.pdf [2005, July 6].

Lindblom-Ylanne, S. and Lonka, K. (2001) Students' Perceptions of Assessment Practices in a Traditional Medical Curriculum. *Advances in Health Sciences Education*, **6**, 121–140.

Morote, E-S. and Pritchard, D.E. (2002) What course elements correlate with improvement on tests in introductory Newtonian mechanics? *Annual Meeting of the National Association for Research in Science Teaching, New Orleans, April 6-10.*

Ramsden, P. (1992) *Learning to Teach in Higher Education*. Routledge, London.