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# Mastering physics?

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## Goals of the research

*MasteringPhysics* is a tutorial software package. The University of Wollongong adopted it for one stream of first-year physics in second session 2004. The goal of the research is to determine the impact *MasteringPhysics* had on examination results in the subject and on student opinion of the subject.

## Research methods and data analysis

Examination marks for the class using *MasteringPhysics*, PHYS142 (2004), are compared with those of (1) classes in the same subject in previous years (1999-2003), (2) a class with many of the same students in the previous session (PHYS141) and (3) a class in the same session with much of the teaching in common (PHYS143). Previous comparisons have been made of the impact of a teaching innovation on student performances in examinations that have involved every student having the 'treatment' and 'non-treatment' for half a session each (Lewis, Harper and Wilson 1991; Lewis 1995), or groups carefully 'matched' for similarities (Sharma, Millar and Seth 1999). While not as sophisticated as these methods, our method of comparison of the cohort using *MasteringPhysics* with the same group the previous session, and a similar group in the same session, as well as similar groups in other years, allows robust conclusions to be drawn.

A quantitative comparison of examination marks in the three subjects is given in Table 1. The means are expressed relative to marks obtained by the one class that used Mastering Physics, PHYS142 in 2004. The most direct comparisons are between PHYS141 and PHYS142 in 2004, and between PHYS142 in 2003 and 2004. In each case the student t-test shows there is no significant (taken to be $P<0.05$) difference in examination mark ($t=1.95$, $P=0.052$; $t=0.285$, $P=0.776$). On this basis we conclude MasteringPhysics has no significant impact on examination marks (relative to the tutorials it replaced).

Considering the examination marks more broadly, it is of interest to note that in 2001 PHYS142 was significantly ($P=0.007$) better than PHYS141 and in 2002 significantly ($P=0.002$) worse. This variation occurred without any (deliberate) variation in teaching. The effect of MasteringPhysics is less than this variation. Over the five years 1999-2003 the ratio of the PHYS142 to PHYS141 mark is $1.02\pm0.11$. The 2004 ratio of 1.07 falls within this range. Likewise, of PHYS142 1999-2003 one year, 2002, is significantly different to 2004, but this difference is not attributable to MasteringPhysics. Interestingly, the greatest consistency is between different classes run in the same session. The ratio of PHYS142 and PHYS143 marks without MasteringPhysics is $1.13\pm0.02$ (1999-2003), and the same, 1.13, in 2004.

Qualitative survey data was gathered from generic feedback for the subject. If students perceive MasteringPhysics as having outstanding features - good or bad - that impact on their learning, this will be clear. An open-ended survey asked what was good and what could be improved in PHYS142. About half (21) of the 44 responses (of 170 students) did not mention Mastering Physics. Only 6 identified it as good, only one of these being strongly positive: 'really forces you to understand the concepts and formulas!' There were 13 negative responses, most (7) complaining of the time needed, others about disconnectedness to text and lectures. In addition, there were 4 very negative responses:

'no mastering physics'. These issues are similar to those identified in surveys at another site, although the feedback from those students was more positive overall (Thompson 2005). We have since conducted a survey specifically on MasteringPhysics; preliminary inspection indicates that the attitudes expressed towards MasteringPhysics are more positive than in the generic survey discussed here.

Table 1. Comparison of examination marks

| | **PHYS141** | | | **PHYS142** | | | **PHYS143** | | | **142 /141** | **142 /143** | **141= 142?** | | **$142_{YYYY}$= $142_{2004}$?** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | μ | σ | **n** | μ | σ | **n** | μ | σ | **n** | $\mu_{142}/\mu_{141}$ | $\mu_{142}/\mu_{143}$ | t | P | t | P |
| **1999** | 0.89 | 0.40 | 123 | 0.92 | 0.38 | 116 | 0.81 | 0.42 | 137 | 1.03 | 1.13 | 0.60 | 0.547 | 1.90 | 0.059 |
| **2000** | 0.95 | 0.34 | 143 | 0.93 | 0.37 | 145 | 0.84 | 0.43 | 115 | 0.97 | 1.11 | 0.64 | 0.523 | 1.87 | 0.062 |
| **2001** | 0.91 | 0.36 | 116 | 1.03 | 0.36 | 145 | 0.91 | 0.39 | 108 | 1.13 | 1.14 | 2.72 | 0.007 | 0.75 | 0.452 |
| **2002** | 0.89 | 0.34 | 122 | 0.76 | 0.29 | 124 | 0.69 | 0.37 | 116 | 0.86 | 1.10 | 3.18 | 0.002 | 6.78 | 0.000 |
| **2003** | 0.91 | 0.35 | 141 | 0.99 | 0.36 | 154 | 0.86 | 0.38 | 154 | 1.09 | 1.15 | 1.95 | 0.052 | 0.285 | 0.776 |
| ***1999: 2003*** | *0.91 ±0.03* | | | *0.93 ±0.10* | | | *0.82 ±0.08* | | | *1.02 ±0.11* | *1.13 ±0.02* | | | | |
| **2004** | 0.93 | 0.33 | 169 | **1.00** | 0.31 | 170 | 0.89 | 0.33 | 146 | 1.07 | 1.13 | 1.95 | 0.052 | | |

(mean, μ; standard deviation, σ) and number (n) of students in PHYS141, PHYS142 and PHYS143, 1999-2004. Marks are relative to the 2004 PHYS142 class, the only class to use *MasteringPhysics*. PHYS141 (Autumn) and PHYS142 (Spring) have almost the same students in any calendar year. PHYS143 runs at the same time as PHYS142 and has 2/3 of the lecture classes and almost all the laboratory classes, but no students, in common with PHYS142. For each year, the ratio of the mean PHYS142 to mean PHYS141 (column 11) and mean PHYS142 to mean PHYS143 (column 12) marks are shown. Statistics to test if the PHYS141 and PHYS142 means are the same in any year (columns 13, 14) and if the PHYS142 mean in 2005 differs from that in any other year (columns 15, 16) are also given.

## Interpretation and conclusion

MasteringPhysics does not have a large effect on the performance of our students in the final examination. Any effect is less than the usual variation that occurs from session to session, year to year.

### Implications for practice

We have found that replacing tutorial classes with MasteringPhysics has no discernible effect on examination marks. This is a non-trivial outcome: it was thought before the trial that MasteringPhysics would be much better (or much worse) than tutorials in preparing students for examinations. It turns out, within the uncertainty of our data, that each is equally effective. The implication for practice is that the criterion of better examination performance does not distinguish between MasteringPhysics and tutorials. So other criteria, such as student satisfaction, staff acceptance, cost and integration with other learning modes, need to be considered in deciding whether to replace tutorials with MasteringPhysics.

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