[O12] JiTT in Physics

Marion Birch and **Niels R. Walet**
School of Physics and Astronomy, University of Manchester
marion.birch@manchester.ac.uk; niels.walet@manchester.ac.uk

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Background

The first year undergraduate intake to the School of Physics and Astronomy at the University of Manchester comprises approximately 230 students, with an average A-level score of AAB. All of these students are required to take the Dynamics module, which covers some simple vector algebra and classical mechanics, in their first semester. This module has had a tradition of rather mediocre feedback on the student satisfaction questionnaires and poor exam results as compared with the other first year modules. However, it is one of the core modules in our first year, and future success seems linked to good performance in this course.

First year modules in the School of Physics and Astronomy have, until now, been delivered in a very traditional manner, typically through two lectures per week. In addition, students undertook a one hour Dynamics 'workshop' per week where they were encouraged to work together in groups in order to solve problems and debate the physics principles. The students' learning was further supported by a one-hour tutorial.

From anecdotal evidence, there are strong indications that the students' attitude towards learning when arriving at university does not always meet our expectations; we also believe that continuing to rely mainly on 'chalk-and-talk' is not preparing our students to take the responsibility for their own learning. Clearly, we are hampered by the structure of the GCSE and GCE curriculum, which often places greater emphasis on the method of answering as opposed to the depth of understanding. The clear break provided by the transition to the university environment is probably the best time to try and install a different ethic amongst our students.

New Approach

In the academic year 2006-07 we changed the delivery of the Dynamics module in several ways:

(i) we used the 'Just-in-Time Teaching' (JiTT) method (Novak *et al*, 1999) as inspiration for our method of delivery,

(ii) we adopted a blended learning approach combining a face-to-face presentation with e-learning and,

(iii) we introduced weekly electronic assignments.

The aims of this innovative approach were:

- To provide a much more student-centred approach to learning;
- To encourage the students to take responsibility for their own learning;
- To instil a deeper conceptual understanding of fundamental physics principles rather than superficial learning to pass exams;
- To increase students' engagement with the material;
- To improve student retention;
- To enhance exam performance;
- To change the students' attitude to learning.

What is JiTT?

JiTT is a pedagogical strategy which was developed in the USA (Novak) in 1996 as a joint project of the Physics departments at IUPUI (Indiana University–Purdue University Indianapolis) and at the United States Air Force Academy. Since then the strategy has been adopted by other disciplines and other institutions worldwide.

The JiTT approach is student–led. In its standard form it does away with traditional lectures in favour of much more student-interactive lectures. The students are required to read up the material in the textbook and do some web-based 'warm-up' exercises prior to receiving any formal instruction on a particular topic. The 'warm-up' exercises are submitted electronically a few hours before the lecture enabling the instructor to see what the students are having difficulty with and what their misconceptions are. He/she is then able to prepare the lecture material according to the needs of the students. This is done just in-time before the lecture, hence the name. The core element of the JiTT strategy is therefore a closely coupled 'feedback' loop whereby the students' pre-lecture preparation affects the content of the lecture. The lecture thus becomes much more interactive, building on the students' prior self-study.

The majority of reports in the literature on the use of JiTT refer to relatively small cohorts of students compared with our first year intake of 230. Therefore we adopted a slightly modified JiTT approach.

Modified JiTT approach

Our modified JiTT approach consisted of five stages for each of 11 weeks, in order:

(i) An introductory lecture

(ii) A period of self learning

(iii) An online test

(iv) A feedback session

(v) A standard tutorial

Introductory lecture
Rather than having the two traditional lectures per week, the students were given a single overview presentation at the beginning of each week. The aim of the overview presentation was to briefly introduce the students to the material they needed to study that week. It was not intended to be a normal teaching lecture but rather to point the students in the right direction and facilitate their further self-study.

Self-learning
A substantial amount of learning material was developed for the University's Virtual Learning Environment, (VLE). The material was structured into eleven topic areas corresponding to each of the eleven teaching weeks of the course. A variety of formats was used within the VLE. In addition to the usual textual material, a large number of 'talklets' (Levitt, 2004), were also incorporated. These small screencasts consist of an animation or PowerPoint presentation, with a recorded verbal explanation, concentrating on difficult concepts or solutions to problems. The idea behind these talklets was that students could study the material at their own pace, with access to some mini-lectures. Physlets (Christian, 2005) (physics java applets) were also included to aid students' conceptual understanding by the use of interactive simulations wherever possible.

Following the overview presentation, the students were then expected to study the detailed material for that week provided on the VLE.

On-line assessment
When the students felt that they had understood the material sufficiently well, they were required to complete an on-line assignment. The assignment consisted of 5 or 6 problems each week, with an estimated workload of a little over an hour. The 'Masteringphysics.com' website provided by Pearson Education as a companion to the students' core textbook 'University Physics' (Young and Freedman, 2004) was used for this purpose. This website provides a comprehensive library of problems for each chapter of the textbook. The problems fall into two classes: (i) Skill Builders (SP) and Self-Tutoring Problems (STP), which have hints which the students can open if they need them, and (ii) End-of-Chapter Problems (EOC) without hints. Students may have several attempts at a problem until they obtain the correct answer. The maximum number of attempts we allowed was six. In all cases, the students are able to request the solution but in the case of the EOC problems, only the answer is provided, not the methodology. One of the powerful aspects of the system is the ability to provide hints based on an analysis of an incorrect answer.

The deadline for submission of the on-line assignment by the students was 2.00 a.m. on the Friday morning of each week, and it counted for 15% of the overall mark for the module.

The Mastering Physics website also provides a considerable amount of data for the teaching staff. The most useful set of data was a comprehensive analysis and summary of how the students had fared on each individual problem, which included,

- The number of students who had completed the problem
- The average time taken to complete the problem
- How difficult the students rated the problem, on a scale of 1-5
- The percentage of students who answered the problem correctly

- The percentage of students who requested the solution
- The average number of wrong answers per student
- The average number of hints used per student

Feedback session

The next component of the module delivery consisted of JIRP (Just in Time Response and Problem) sessions which were held each Friday afternoon. For these sessions the cohort of 230 students was divided into two groups and separate parallel sessions run for each group.

The feedback data from the Mastering Physics program were reviewed every Friday morning. Unfortunately, the usefulness of these data were somewhat limited by the fact that the aggregation time is based on a US timescale, which was not very convenient for us (between 10-12 in the morning UK time). Nevertheless, the data available did give a good indication of the areas the students were finding difficult, enabling the content of the JIRP sessions to be decided. If the majority of the students had experienced difficulties with specific problems, these were discussed. Additional problems were also included which either emphasised a point or concept, or were more challenging than the Mastering Physics problems. This consolidated students' understanding and helped to prepare them further for tackling the tutorial problems set for that week. 'Warm-up' questions were sometimes used at the beginning of these sessions to generate discussion of particular issues or concepts.

Tutorial sessions

Finally, the students were asked to attempt a set of tutorial problems, for discussion in a small-group session (4 students) the week after the JIRP session. The tutorial problems set each week were generally more complex than those of the on-line assignments, so that the students' understanding of each week's topic was consolidated and their analytical skills gradually developed.

Outcomes

Successes:

- The majority of students (approx 95%) submitted the on-line assignment each week. This submission rate was far greater than that for normal tutorial work.
- Results for the mid-semester test and the end of module examination were better than for previous years, the average mark for the latter increasing from 50% last year to 67% this year, with a similar exam.
- Favourable feedback was obtained regarding the talklets on the VLE. Students did find these useful for the reasons intended, i.e. they could have the solutions to problems explained to them again, if they had forgotten, or had not followed the explanation given in the overview lecture.

Pitfalls:

- Feedback from the student satisfaction questionnaires was disappointing. The students complained about having only one lecture per week rather than two.

- Students' expectations were not met and despite being reminded on numerous occasions that they needed to study the material on the VLE, many resented having to do this. They did not appreciate the difference between the overview lectures and the normal traditional lectures that they were receiving for the other modules. They expected to be taught all the material in the one lecture and many of them were quite indignant that they should be expected to follow these up with self-study on the VLE.

- Many of the students did not like using Mastering Physics.

- The default penalty for using a hint on the Mastering Physics assignments was set too low (only 2%). This will be set higher in future. Some students just clicked their way through the hints in order to get to the solution without understanding the underlying physics. They quite openly admitted this when they came to the JIRP sessions.

- Attendance at the overview lectures dropped rapidly to about 50% as soon as students realised that the material was available on the VLE.

- Attendance at the JIRP sessions was not good either. This was probably due in some part to time-tabling problems: in the second half of the semester it was the only session the students had on a Friday afternoon.

- Students generally managed to work their way through the Mastering Physics problems when they were provided with hints, i.e. the SB and STP problems, but found great difficulty when these were absent, i.e. the EOC problems. This caused a great deal of frustration for many students, to the extent that we avoided the use of problems without hints in the latter part of the course.

Discussion

Examination performance has been significantly enhanced this year. However, the new method of delivery has met with resistance from the students, since it did not meet with their expectations. Even though a 30 minute presentation was given to them during Freshers' week, explaining how the module would work, the idea of the overview lecture and the need for them to study the material on the VLE, many students were very reluctant to take responsibility for their own learning. It is interesting that Duncan, 2005 also reported 'shattering' students' expectations when a classroom response system or 'clicker' system was introduced at the University of Colorado to promote more interactive lectures. Many students found the change disconcerting and Duncan emphasised the need to explain repeatedly the purpose and benefits of the new approach to the students.

It was unfortunate that the Dynamics module was the only module being delivered using the new approach. All the other first year modules consisted of two traditional lectures per week which were more like the type of 'spoon-feeding' instruction the students had received previously at school. Consequently students compared the overview lectures with the more detailed traditional lectures they received for their other modules and did not appreciate the need to do more self-study for Dynamics. They felt that a different mindset was required for Dynamics, a mindset which was quite alien to them.

New students are generally unaware of the completely different learning culture at university. There is much evidence of this in the literature. For example, Redish *et al*, 1998 performed a very comprehensive survey of students' expectations upon entering university and how these expectations critically affect students' response to a course. They describe typical students entering the first year of university as 'binary thinkers' who believe that it is the responsibility of the lecturer to convey knowledge to them rather than appreciating the need to be proactive in developing their own understanding.

It is debatable whether the idea of students immediately taking responsibility for their own learning in the first semester is too radical a change given their previous experience of school education. When Price, 2006 introduced a WebCT package for first year chemistry students at the University of Bath, he found that it was hardly used in the first few weeks of the course because the students were overwhelmed by the number of new procedures and activities upon entering university. However, Redish *et al* argue that the change of context provides a valuable opportunity to change expectations but they do acknowledge that this is a not a trivial exercise. It forms part of the 'hidden curriculum' and it may take several attempts to get it right. There are clear signs that we have made a difference in our first attempt, but the negative reaction probably detracts from the effectiveness of our message!

One of the main surprises of this work was the resistance against using the masteringphysics.com web-site for course work. We intend to perform a detailed analysis of the problems in the near future, but initial indications are that we should

(i) Manage students' expectations of the site better;

(ii) Make sure all questions have hints;

(iii) Redesign the hints, so that they will not allow a 'click-through' approach.

We were probably somewhat naïve in our expectation that questions that work well for sizable groups of US students would work for our students, considering the different teaching styles and prior training.

Conclusions

The modified JiTT approach did require students to take more responsibility for their own learning and because this was quite different from their previous school experience, it was met with some resistance. Nevertheless, by the end of the first semester, students had successfully mastered the material to the extent that their examination performance was significantly better than in previous years.

In future, greater attention will be given to the management of students' expectations when entering university, in order to develop the culture of independent learning as early as possible.

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