[O27] LeAP interaction: towards curriculum change in HE

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ABSTRACT

Although problem-based learning (PBL) is a well-established methodology in several scientific and technological disciplines, attempts to introduce it into physics education provide an interesting insight into the management of change in higher education (HE). This paper will describe experiences from projects in a variety of institutions implementing curriculum change towards PBL. It will identify factors that predispose implementations to successful outcomes and embedding of enhanced practice.

On the one hand we have the problem-based learning (PBL) community preaching the new panacea – a teaching method you really can rely on. Put your students together in groups, given them a meaningful and sufficiently complex, open-ended real-world problem to get their engagement, offer some gentle guidance and watch them research the problem, find a (not 'the') solution and see how they learn new and difficult material, which they will own forever (1). Surely the evidence must tell us how much better this is than the traditional methods. On the other hand we have the 'proud to be traditional' tradition, which produces some really good students and excellent reports from external examiners. Surely the evidence points to no real problems with the traditional methods. Can both views be right?

Two questions to begin with: can we really demonstrate anything wrong with the traditional approach? And can we prove that PBL does any better?

Bertand Russell (2) gives us the following warning about the one-time popularity of Hegelian philosophy. Hegel's major works are very difficult to understand – you have to spend quite a large fraction of a lifetime to even partly master them. Academic philosophers having put in this effort and achieved the status of Hegelian expert find it difficult to admit that the great works are less than wholly meaningful and that their lifetime's work has been a waste of time. Is this the dilemma of the PBL adherents? Or of the traditionalists?

Outside Physics there is at least some possible evidence beyond the anecdotal for the efficacy of PBL. The original introduction of PBL in medicine led to measurable improvements in the propensity to keep up to date with new developments amongst PBL trained doctors. Retesting of engineering students in Maastricht after a year's break showed significantly greater retention amongst PBL-trained students (3). For obvious ethical reasons it is difficult to get extensive and reliable comparative data, although the effect of co-operation on learning has been widely explored (4). Some claims to show that PBL itself has at most marginal benefits have been challenged (5).

When we turn to Physics matters are even less clear. Bowe (6) in DIT was able to compare two first year classes taught the same material, one by PBL and one by lectures, and to show a large benefit in retention rates and engagement amongst the PBL students, although not a large difference in examination performance. On the other hand, Lennon (7) in Dundalk has found a large improvement in one first year class using PBL in end-of-year examinations. Although the novelty effect cannot be ruled out here, the result is in agreement with the force concept inventory (FCI) approach (8), which showed a factor 2 improvement (in the FCI defined gain) in the ability to manipulate force concepts amongst students taught through PBL. The stark fact is that none of these data relate to the 'good' physics students in major UK institutions.

The other way of looking at this then is to ask whether there is any evidence that change is required. The Hegelian antithesis holds here too in a way. Staff who have spent half a lifetime learning how to lecture well are unlikely to come to the conclusion that they should never have been lecturing at all. Students having put an inordinate amount of effort in choosing the course that was right for them then, somewhat strangely, assume that all courses use the same approach to teaching: they have been led to expect that university courses are taught by lectures, supplemented, if they are lucky enough to go to a posh university, by tutorials. Students, having trusted their entire education to a department, appear reluctant to criticise their own institutions and their views are usually that no major change is required.

Finally there is a lot of inertia in the system. There are a number of reasons for this. The Research Assessment Exercise (RAE) weightings on funding coupled with the inelasticity of student numbers, mean that departmental resources are more likely to be directed to research activity than to changing teaching practice. External examiners give their approval to systems they know: no one thinks that they have to prove that lectures work. (It is the students' fault if they do not.) I recall a subject review visit in which reviewers spent the fours days bemoaning how much better university teaching ought to be, and then awarding full marks to the department for fulfilling their stated aims and objectives.

Project LeAP was set up through the HEFCE fund for the development of teaching and learning to investigate the use of PBL in various modes and contexts in physics and to disseminate the results. From our visits to about ten departments in the UK we can characterise the various negative responses to PBL in physics as follows.

(i) Our quality indicators tell us that no change is required.

(ii) Not invented here; the PBL method was designed for professional education and may work well in medicine and engineering, but there is no evidence that it works in physics and may well be ill-suited for leading physics departments.

(iii) PBL may have been shown to work for some students, for example high-flyers who can be trusted to take responsibility for their own learning, or weaker students who need motivation, or students for whom physics is not their major study, or at school level, or in the early years of a course when we are not trying to teach relativity, or in the later years of a course when students have mastered the core material, but is not, really not, suitable for 'my' students.

(iv) We would like to introduce PBL if we could, but we cannot, because of (a) staff opposition (b) opposition from the HoD (c) the RAE (delete as applicable).

(v) PBL cannot (?) be used to teach general relativity therefore it cannot be any good.

If we are going to find a significant case for the introduction of PBL into physics clearly we must recognise from these findings that thus far we are looking in the wrong place. Where PBL has been introduced as a significant component of physics teaching it has been through leadership from senior management (the University of Delaware for example), or under extreme pressures, for example from severe difficulties of recruitment or retention. *These examples are characterised by a vision that PBL is not a* *more or less effective teaching method, but represents a cultural change*. PBL is about providing not only a different, but a coherent, learning environ-ment in which the student prior learning, discipline objectives, assessment and community aspects are aligned in a way that is rarely the case in conventionally taught courses (9).

PBL is therefore a way of addressing the key problem with current higher education in physics: that *we have an elitist system operating, relatively unsuccessfully, in a mass market*. By an elitist culture I mean an approach that requires students to have mastered a significantly large body of knowledge before they can be expected to engage meaningfully in the professional process of the scientific discipline. While this is a common assumption in many sciences, it is manifestly not the case in all disciplines. One only has to mention the empathetic approach to history or the introduction of creative writing in English at the level of primary education. Attempts to address the appeal of physics to a mass market through curriculum development, while welcome in ensuring a curriculum with contemporary relevance, do not appear to have altered the elitist culture.

It is unnecessary to rehearse again the need for some success in increasing the appeal of physics in HE. PBL represents *an* attempt to address this problem at source: it is based on the creation of an environment of engagement in which students learn science by doing science, that is by solving scientific problems through (guided) scientific research.

Our experience of visiting UK and overseas departments who have introduced PBL in a substantial portion of the curriculum has shown that PBL, although currently rare in physics departments, can be implemented in a wide variety of institutions. However, some common factors can be identified which may indicate potential for successful implementations.

(i) A group of colleagues with a similar vision: although there can be individual champions of PBL their work is unlikely to outlast their own tenure.

(ii) A supportive management who see PBL as a component of the institutional teaching and learning strategy.

(iii) Identifiable issues to be addressed: these could include retention and recruitment as well as attendance and student performance.

(iv) Reasonable expectation of outcomes: it may be necessary to introduce PBL over a period of years and to expect substantial revisions over that timescale.

(v) Time for preparation, but not too much time so that preparation is focussed. The time budget needs to include problem development and staff training.

(vi) An appropriate physical environment: PBL is possible in tiered lecture theatres but it is easier in flat teaching areas with moveable furniture.

There is some evidence of suppressed recognition of the potential of PBL. In a survey carried out in the LeAP project at least 40% of physics departments in the UK claimed to offer some PBL or PBL-like activities in their programmes (from a response rate of just over 50%). What therefore are the impediments to expanding this, not to an exclusive use of PBL, but to a situation in which the traditional lecture-based methods are used, as appropriate, in a PBL environment, not vice-versa? It seems to us that there are at least two major obstacles.

One is the lack of PBL resources in physics. Few lecturers construct a lecture course from scratch: there are books, problem sets, web resources, past examination papers and often their own experience of being lectured to (if not their actual notes!). With PBL there are no textbooks of problems, no established assessment routines and the web resources mostly seem to have been written for different types of students (as indeed most have). Another is the exposure to failure. We often expect to hone a lecture course after its first delivery and we have to accept that, at least in our experience, a PBL problem is rarely perfect first time. The usually quoted complaint that PBL takes a lot of resources to develop has not been our experience if the comparison is made fairly with the time taken to develop a lecture course or a new laboratory experiment from scratch. Nor is it our experience that the courses are excessively labour intensive to run, although one can get carried away with the assessment load for both students and staff, and it does require appropriate time for staff development for facilitation.

Thus, Project LeAP is attempting to contribute to overcoming these obstacles by providing a freely available bank of PBL problems of various types, and in sufficient quantity, to act as a resource for PBL developers, together with supporting resources for assessment and facilitator training. The CETL in Innovative Physics Teaching will take on this role when the LeAP project comes to an end.

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