[O11] Truth and transferability: discovering physical science educational realities

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Abstract

This project aimed to investigate if perceived successes in the Physics Group-Based Research Projects (GRePs) at the University of Leicester could be transferred to the core curricula. Although both the GRePs and the core curricula utilise problem-based learning both staff and student informal feedback had been more positive about GRePs, which focus on a range of specialist areas. Therefore the project involved uncovering the truths of the perceived successes in GRePs, i.e. criteria for success and how these manifested themselves, then investigating if these manifestations were appropriate in the new context of the core curricula. Three research methods were utilised and their results triangulated leading to the conclusions. Firstly, audio of key GRePs' staff interviews was recorded and later transcribed. Secondly, student assessment results of GRePs and the core curricula were gathered. Thirdly, students were surveyed concerning their impressions of GRePs utilising QuestionPro, an online survey instrument. The project's conclusions may be useful to staff as they consider rolling out GRePs-like approaches to the core physics curricula. Finally, reflections born of the study in the light of the pedagogical research program were captured.

Introduction

Truth is a notoriously slippery customer although this may entirely depend upon your own perspective. Certainly physicists may like to believe that it is possible to objectively describe reality (whatever that may be) through the derivation of models usually in the form of laws which society then reifies in numerous school text books as we all have doubtless experienced. However, any physicist worth her or his salt will also be very capable of discussing the limitations of models in that they are (possibly used with a qualifying 'for the time being') approximations of reality particularly as they allow our descriptions of the aforementioned phenomena to be honed over time. This is basically the tenet of positivism, that some kind of absolute description of the Universe is possible.

Post-positivism, on the other hand, refutes this tenet by almost arguing for the opposite relationship between the observer and the observed. That is, it recognises – in a way strangely similar to Heisenberg – that the observer and the observed are inextricably intertwined in the same reality. Thus the outcome is that objective descriptions of reality become trickier to derive. So, instead of placing ourselves at the centre of the Universe in an almost Copernican revolutionary way post-positivists seem to argue that the Universe instead surrounds us. As such it becomes illogical to describe a reality which we all share since your view of the Universe may look completely different to mine.

For some time educationalists seemed to argue these conflicting viewpoints quite ferociously. Luckily, educationalists may now be more inclined to recognise that positivism and post-positivism, at least in terms of methods if not methodology (or philosophical origins) can be used in harmony rather than diametric opposition. Thus, today we may find qualitative methods reminiscent of post-positivism being used alongside quantitative methods more reminiscent of positivist approaches. Indeed, both perspectives are used within the research project described here. This does not, however, mean that this 'marriage' is necessarily a happy one. Indeed, at times these unlikely partners undoubtedly quarrel as shared understanding is hammered out at the interface of their respective perspectives. However, these more general discussions will be saved for the end of this paper. First, the context for this research project is established. This approach in itself helps to paint a 'thick description' (Lincoln and Guba, 1985) of the project with the intention of furnishing transferability – the post-positivist 'equivalent' of generalisability (Barker, 2003, p.18). In other words, we describe our 'truth' or perspective in the most complete way possible despite or rather because of our inherent limitations. Hence, when the future interested scientist attempts to observe our Universe from their own 'truth' or perspective they should be aware of the artefacts of our own fallibility.

Context

In one form or another Problem Based Learning (PBL) has been utilised at the University of Leicester since the 1980s when it was actually then closer to what was known as Resource Based Learning. This hints at one of the key problems in describing research concerning PBL notably that it is actually a plethora of methodologies which can vary greatly even within disciplines but especially perhaps across them. At the University of Leicester, Department of Physics and Astronomy there is a model in use which has been honed over the years and aims to standardise the approach although other models such as the Maastricht model, the Medical School Model and the Floating Facilitator Model, etc. (Raine and Symons, 2005) are generally recognised amongst practitioners.

PBL at the University of Leicester is currently utilised for the Group-Based Research Projects where students typically work in groups of four on problems presented as staged scenarios. Facilitation is provided, usually by postgraduate students, to guide students towards solutions to the problems. Typical of PBL the problems are designed to be open-ended in that any number of solutions may exist. Thus the role of the facilitator becomes one of treading a fine balance between supplying answers to student questions and simply supervising students' own inquiry. Thus the facilitator may supply methods and pointers to resources to help students reach the solutions. Usually after several such facilitation sessions and students' own independent work academics from the Department may talk to students to obtain feedback as to progress and help with seemingly intractable problems as appropriate. Finally academics will be involved with coursework assessment.

Currently the possibilities offered by PBL across the curriculum are being investigated at Leicester. Thus the recent Project LEAP had a number of aims including 'To disseminate and encourage the adoption of best practice in PBL in physics and astronomy' (**www.le.ac.uk**/**leap**, accessed 1/3/2007). More recently the University of Leicester formed part of a consortium, together with the University of Reading and the Open University, for a successful HEFCE bid to establish a Physics Innovations Centre for Excellence in Teaching and Learning (piCETL).

Aims and Objectives

The aims of this research programme are broadly to investigate the effectiveness of PBL at the University of Leicester. Obviously this is from all perspectives, including students, academics, support staff and administrative staff. More widely, if resources allowed, it would be interesting to examine public perceptions of PBL including those of employers and parents. However, for the time being the objective is to investigate one aspect of PBL practice which, as already stated, has been deemed in folklore terms at least, to have been a success. Thus the point of this research is to concretise this claim leading to the following research question.

Research Question

Simply, the research question is '**can perceived successes in the Group Based Research Projects (GRePs) be transferred to the core curricula?**' The means of answering this are described below.

Methodology

As described above the methodology to be used is not simply taken from one finely demarcated perspective but from a multitude of such perspectives. Hence, this postmodernist (perhaps) bricolage of methods may not easily be named in terms of one simple methodology. Instead it borrows from positivist and post-positivist systems of thought although admittedly the latter is acknowledged more than the former. Hence, it sometimes proves necessary to qualitatively interpret quantitative data although it is believed that this relationship is unidirectional in that problems may arise if a quantitative analysis is attempted of qualitative data due to the fundamental differences in assumptions underlying each perspective. These statements are illustrated next.

Method

First, key GRePs and some PBL staff were interviewed resulting in 7 audio recordings. A total of sixteen questions were designed to be used in a semi-structured interview style. That is, if something of interest emerges during the process of interviewing with this approach the interviewer is free to explore these issues rather than rigidly adhering to the questions. Thus the questions *frame* the interview.

Second, students were asked to volunteer to take part in the study. Initially the intention was to also interview students but it soon became apparent that, due to the large number of volunteers and given the limited resources for the study, this would prove infeasible. Therefore, after some investigation, the decision was taken to utilise an online questionnaire – where students could log on and answer a variety of questions utilising various styles of questioning. The software used, **www.questionpro.com**, also allowed tracking of participants, seamless emailing of reminders and quite detailed and visual analysis methods as well as downloading of results to Microsoft Excel. This latter approach was taken for our purposes.

Third, individual GRePs results for each of the 8 options and overall assessment results which utilise PBL were obtained. These have been subjected to a simple statistical analysis, for example calculating means and standard deviations, then *qualitatively*

interpreted through visualisations. Thus it will be possible to *triangulate* the multiple methods which will help to ensure a complete and consistent picture is obtained of the state of GRePs and PBL, as reflected by staff and students, at the University of Leicester.

Analysis

The interviews were analysed by reading them with the research question in mind and highlighting those speech utterances which both relate to the question and summarise a series of exchanges between the interviewer and interviewee. Thus the result of this exercise is a series of 'chunks' of data which pertain to the research objectives. These chunks can then be categorised and reported as results of the analysis.

Fortunately, the use of the online questionnaire tool, QuestionPro, greatly simplifies both the management of respondents' responses and subsequent analysis. For instance, it is possible to produce online reports as to how many respondents have completed the survey so far. Furthermore, when the survey closes, it is possible to produce further summary reports which will, for instance, produce percentages of responses for Likert scales together with mean averages, standard deviations and variances. Short answer responses were also collated. Each question's answers then form a separate 'sheet' in a form that can be downloaded and displayed in Microsoft Excel.

Finally, all relevant assessment results were obtained either already in the form of an Excel spreadsheet or were subsequently entered into such. Once the assessment results are in this form it is relatively simple to begin to interact with the data. First of all this involved converting the results into the same type, i.e. percentages. Next it was necessary to compute mean averages (including confirmation of those already obtained) and standard deviations. These were then plotted for the core curricula and GRePs before being interpreted, as described next.

Results

25 students completed the survey out of 40 volunteers (asked to participate during one first year and one second year lecture). 76% of the group were males. Out of 8 GRePs, most people took 'astrophysical techniques I' (12), 'the earth's space environment' (8) then 'astrophysical techniques I' and 'spacecraft imaging systems' (both 5).

With regard to how GRePs successes can be transferred to core curricula one student said 'I think that projects should reflect more of what goes on in the real world, such as SpaceCraft Imaging systems – we used webcams and basic PC software rather than similar industry systems. For the Space Science and Technology course this should have been covered in more detail.' On the other hand a representative dissenting comment was 'They can be used as a support to the curriculum, but not as the main method of study. More detailed explanation of the key concepts is necessary to some students.'

Students see teamwork as the skills especially gained in GRePs. Most students (44%) thought the best format for GRePS is one lecture followed by one tutorial (repeated). However 60% felt GRePs are 'too rushed' although the majority felt time spent on labs is 'just right' (55%). Impressions of the workload were almost equally split: 'the workload is just right' (45%) and 'there's too much work' (40%).

From interviews with staff it emerged that some students may not distinguish between

GRePs and the core curricula so a question was asked where they could state the differences. It was fairly clear that the presupposition was unfounded, e.g. 'You are expected to know more than you were taught.' and 'For the group research, you have to go away and look up things for yourself. In the core curricula, a lecturer will teach you the material.' More generally regarding PBL a slim majority felt it 'worked' (48%), a larger majority felt that enough time was allowed (68%) and 21 of 25 participants felt that feedback was adequate. A further slim majority (52%) felt that there is 'sufficient equipment'.

When asked if they had any further comments to make about PBL 17 out of 25 participants made, in the main, rather negative comments. The following is fairly typical:

> 'There were plenty of problems, but not a lot of learning. The idea was supposedly that we were given a problem that we were to solve in our own way, but we were only given set equipment so all ended up doing the same thing. Other possible solutions could've been carried out if the equipment was available. Also the 'no help' rule seems foolish, I understand it was to make us think on our own and come up with the solutions, but when we are unable to do anything and just sit there for 3 sessions making no progress it seems a complete waste of time.'

As to suggestions for future improvements to PBL at Leicester they range from negative, caustic criticism to something a little more useful. Examples of the latter include:

> 'Give students feedback on PBL projects! Make PBL more interesting, relevant and educational - giving students the transferrable AND professional skills they need once they graduate. Organise PBL better, make handouts more relevant, clearer, and with more necessary information. Find lab demonstrators who know what they're doing and aren't uninterested/apathetic. DO NOT replace traditional laboratory experiments with PBL. Allow longer/more lab sessions for PBL experiments to be satisfactorily completed. Allow students more flexibility and scope in solving problems, rather than having one solution.'

> 'Either scrap it totally and go back to traditional laboratory experiments, or implement the changes students, such as myself, have suggested and conduct another survey at the end of the next academic year to see how satisfied students are then.'

The vast majority of participants expressed that they move from 'traditional' 'school-based learning' to PBL with difficulty: 12% 'with great difficulty', 36% 'with difficulty' and 36% 'with moderate difficulty'. In terms of the organisation, delivery and facilitation of GRePs a slight majority felt it was 'slightly poor' (24%), 'good' (28%) and 'good' (24%) respectively. In terms of the organisation, delivery and faciliation of the core curricula larger majorities felt it was 'good' (32%), 'good' (52%) and 'good' (36%) respectively.

Question 10 of the questionnaire asked students to indicate how they **felt** about their PBL experience at Leicester. The composition of the eight ensuing scales is based upon a cognitive model of emotions by Ortony, Clore and Clare (1990). The graphs (**Figure 1**) thus *qualitatively* indicate where students rated themselves along a continuum as indicated. Further dissemination may report this in more detail.

Figure 2 demonstrates the relationships between mean percent averages and their standard deviations for all of the University of Leicester undergraduate Physics modules

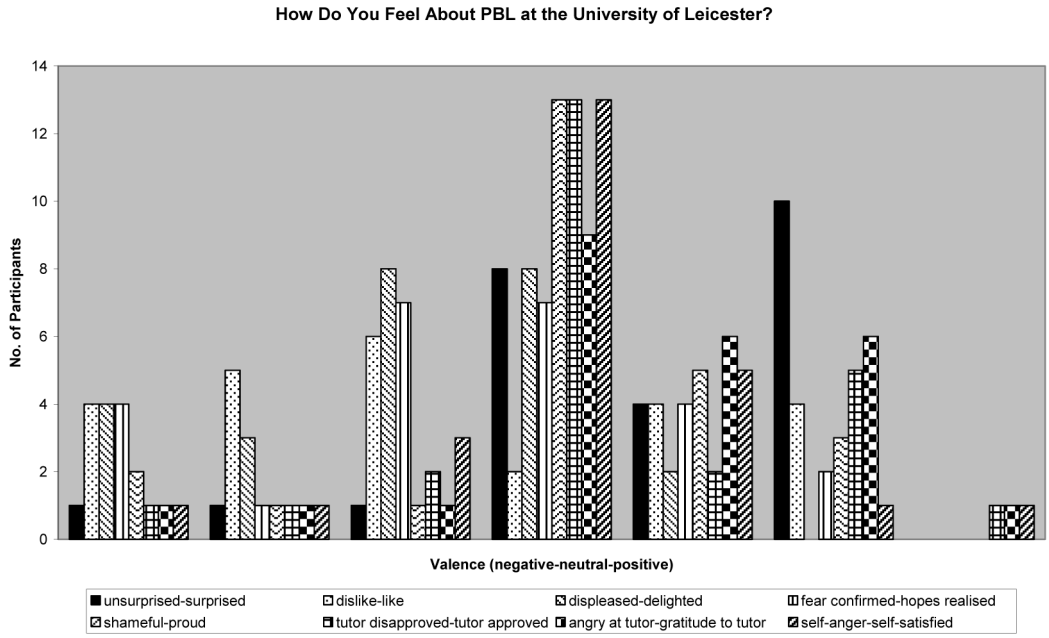

Figure 1: Student 'feelings' towards the PBL experience

which currently utilise Problem Based Learning. Notably, as **Table 1** demonstrates, modules can be compared both across years and whether they belong to the 'core curricula' or the GRePs. The main result here is that although the First Year Core Curricula subjects compare favourably with their like in the Second Year for the GRePs the First Year assessment results seem to *qualitatively* under perform when compared to their Second Year counterparts although admittedly the data is a little sparse. Since this result may have been commented on by tutors the interviews should be examined. However, unfortunately time has not yet allowed a complete analysis so this forms part of future work.

Conclusions

Perhaps the most obvious conclusion, evident in **Figure 2** as well as reported by academics, is that students who enter the First Year and are asked to pursue PBL in GRePs in their first term are unprepared for the differences between this approach and those employed in their previous studies. This is also evidenced in the survey. One opinion expressed by an academic was that Physics at Further Education and lower levels currently contains little laboratory based sessions. Hence the feeling was that students do not have the necessary skills with which to engage in research-based or Problem Based Learning. Certainly it does seem that there is a clear discrepancy between the achievements of students taking GRePs in the First Year and more successfully in the Second Year.

Students seemed quite divided as to their opinions regarding PBL. While some felt that it was a bona fide way to approach Physics others felt that it was not. It does seem though that concerns about adequate resources being available, i.e. availability of equipment, are shared by both academics and students. Certainly it seemed there was a general consensus amongst students about the need to allow adequate time to undertake PBL. Both academics and students also expressed concern about the quality of facilitation.

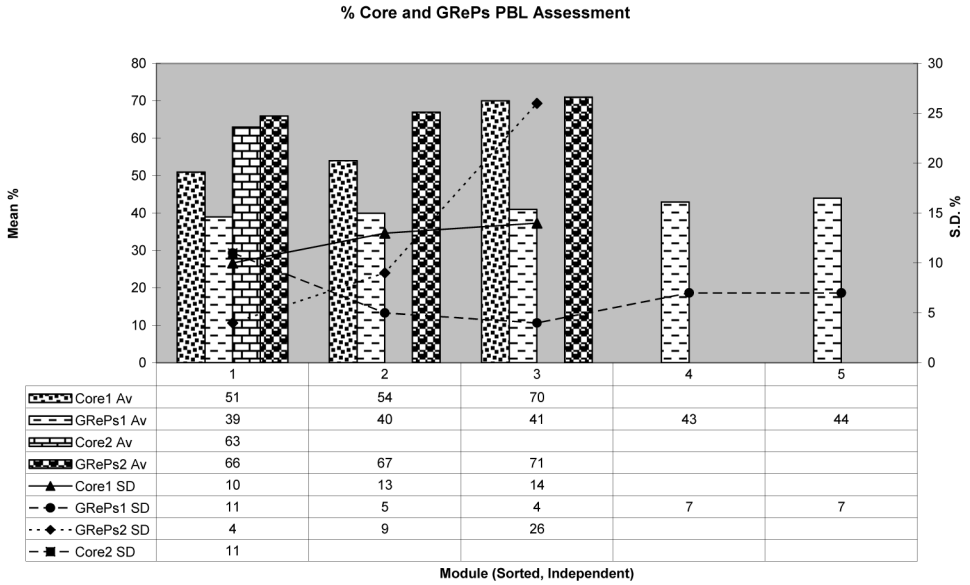

Figure 2: Averages (Av) and Standard Deviations (SD) of PBL assessments

	Core1	GRePs1	Core2	GRePs2
S1	Crosswinds	Planetary Cratering	Laboratory Physics 2	Spectroscopy II
S2	AC Theory	Nano-Aerosols		Astrophysical Techniques II
S3	Optics	Spectroscopy I		Spacecraft Imaging Systems
S4		Astrophysical Techniques I		
S5		Earth's Space Environment		

Table 1: Index to Core Curricula and GRePs Subjects in **Figure 2**

In terms of generalisations of student 'feelings' towards PBL although there was an indication of students being 'displeased' and indicating 'dislike' towards PBL they also indicated 'gratitude' and 'pride'. This would indicate that there is a foundation upon which to initiate improvements in PBL. These are discussed next.

Recommendations

Probably the most obvious recommendation based upon this research is to move GRePs from semester one in the First Year to semester two. In this way students can become more accustomed to Higher Education level Physics prerequisite skills, particularly laboratory-based skills, receiving training as appropriate. Fortunately, piCETL is currently acquiring new laboratories as part of the associated HEFCE funding so this may address the concern regarding equipment availability. Additionally, it is suggested that training of facilitators should be re-examined in the light of these research findings and steps possibly taken to improve the current provision.

Thus, with these recommendations in mind, the 'perceived successes' of GRePs (with the caveat that the perceptions may not be the whole 'truth') could be transferred to the core curricula.

Discussion

This project has shown that it is possible to inquire as to the current perceptions of teaching practice in Higher Education. It has also attempted to show how it may then be possible to expose the reality of the situations – or Universe – being studied as the analysis is moved towards a less biased basis through methodological 'rigour'. However, in-keeping with the opening salvo of this paper it is almost impossible to remove all bias as, at the simplest level, this research project has taken place within the context which it is purporting to study. Hence, there may be inherent restrictions as to the degree of 'truth' it is possible to obtain, in-keeping with Heisenberg.

Truth will forever remain a 'slippery customer'. The purpose of science is to ever move us further towards that goal of a description of reality. However, whilst being a noble pursuit worthy of many great adventures, this pot of gold is likely to remain undiscovered at the bottom of the most beautiful and enigmatic of rainbows.

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