RESEARCH DIRECTIONS

The Attitudes Towards, and Experiences of, Laboratory Teaching in Year 1 Chemistry and Physics University Courses

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Abstract

Our study compares the attitudes to their lab experience of students in two science subjects, Chemistry and Physics. We found this to be consistent across the disciplines. Laboratory learning is appreciated by students, as a means to develop knowledge and skills. Many of the benefits that students report are in line with the aims set out by the American Association of Physics Teachers (AAPT) for practical teaching. This suggests that laboratory teaching in both subjects is meeting its goals and providing a valuable contribution to the education of students.

Keywords: laboratory learning, physics, chemistry

Introduction

Practical work has long been regarded as an indispensable tool in the education of physical science students (Hanif *et al.* 2009). In general this takes the form of either teacher-led demonstrations or of experiments carried out by the students themselves (Gee & Clackson 1992). This is considered valuable since it allows science to be taught in a manner similar to that in which scientific research itself is generally conducted - i.e. in a laboratory (Hodson 1996).

Laboratories, however, are expensive to run in terms of resources and time. It is therefore important to decide if the time is well spent. Do laboratories have clear learning goals, and do the

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students consider the experience valuable and one in which they can develop useful skills?

A previous study (Hanif *et al.* 2009) showed that students in their first year of a physics degree held generally positive views towards their laboratory experiences. In this report, the same survey tool was used to compare the views of level 1 physics and chemistry students to see if there were common issues between these two, experiment-heavy courses. The work was carried out in the Schools of Chemistry and Physics & Astronomy at the University of Glasgow.

Goals and objectives associated with practical teaching in undergraduate physical science subjects

The American Association of Physics Teachers (AAPT 1997) published a list of five common goals for laboratory teaching:

i. The art of experimentation: the lab should engage each student in significant experiences with experimental processes.

ii. Experimental and analytical skills: the lab should help students develop a broad array of basic skills and tools of experimental physics and data analysis.

iii. Conceptual learning: the lab should help students to master basic physics concepts.

iv. Understanding basic knowledge of physics: the lab should help students understand the role of direct observation in physics.

v. Developing collaborative learning skills: the lab should help students develop collaborative learning.

Whilst these goals and objectives were stated for physics laboratories, they can just as easily be applied to chemistry facilities.

Study design and procedure

The attitudes of the students were collected by paper surveys, issued in the final laboratory sessions of their first year at university. These surveys asked them to look back upon the laboratory work in the particular subject during their first year at university.

The students in each class were not necessarily destined to study those subjects further. The University of Glasgow admits students to a particular college, rather than to a course, so a significant number of students in any level 1 class will not be intending to study that subject beyond their first year.

The survey used a mixture of tick box questions in the Osgood *et al.* (1957) and Likert (1932) formats, and free-text questions.

The written responses to the free-text questions were coded using a general inductive technique (Thomas 2006) to identify common themes.

Results

The surveys were completed by 187 chemistry students and 181 physics students.

The first question asked the students to assess their undergraduate laboratory experiences. They were then presented with a series of paired words or

Table 1 Opinions on laboratory experiences in their subject

	Group[1]	Positive %	Neutral %	Negative %	
Useful	C	74	23	3	Useless
	P	77	20	2	
Understandable	C	54	41	5	Not understandable
	P	70	28	2	
Satisfying	C	44	49	7	Not satisfying
	P	40	57	3	
Interesting	C	36	50	14	Boring
	P	35	57	8	
The best part of subject	C	43	52	5	The worst part of the subject
	P	20	61	19	
Enjoyable	C	56	42	2	Not enjoyable
	P	47	46	7	

[1] C = Chemistry; P = Physics

statements, separated by six tick boxes. They were instructed to place a tick in the box which they felt best described their view of each pair. For ease of interpretation, these six boxes were then combined into three categories – positive, neutral, negative – and are presented in percentage format in Table 1.

Students clearly believe that laboratory work is useful and understandable. They are less positive in other areas, but the negative response never dominates. Whilst there is some variation between the two disciplines, in all cases the pattern peaks in the same section for each statement/word. This suggests a common experience within these subjects.

The second question asked students to respond to a series of statements, on a Likert scale, from strongly agree through to strongly disagree. The results are shown, in percentage format, in Table 2.

Students clearly feel that laboratory work helps their learning, and that they are given good levels of support in their laboratory classes. They believe that attempting preparation work for the laboratories assists their work, which is in line with research in this area (e.g. Johnstone *et al.* 1998). As for the responses to the first question, the broad patterns between the two subjects are comparable.

For both questions 1 and 2 there were some statistically different responses between the groups, depending on where within the broader classifications the distributions peaked, but this is not discussed here.

Table 2 Students' experiences in laboratory work

	Group[1]	SA/A[2] %	N[2] %	SD/D[2] %
I prefer to have written instructions for experiments.	C	94	5	1
	P	92	8	0
Laboratory work helps my understanding of course topics.	C	73	21	7
	P	78	17	4
Discussions in the laboratory enhance my understanding of the subject.	C	66	25	9
	P	80	15	5
I had few opportunities to plan my experiments during the lab work.	C	35	41	24
	P	29	51	21
I felt confident in carrying out the experiments in my subject.	C	75	16	9
	P	55	31	14
The experimental procedure was clearly explained in the instructions given.	C	84	12	4
	P	68	21	11
I was so confused in the lab that I ended up following the instructions without understanding what I was doing.	C	19	30	51
	P	16	30	54
There was good linkage between experiments and the relevant theory.	C	57	27	15
	P	71	21	8
I was unsure about what was expected of me in writing up my experiments.	C	30	26	44
	P	34	22	44
I only understood the experiment when I started to write about it afterwards.	C	24	36	40
	P	16	28	56
The amount of time given for each experiment was sufficient.	C	95	4	1
	P	82	10	8
The demonstrators provided valuable assistance with my work.	C	76	15	9
	P	81	13	6
Attempting the tutorial questions before the lab was very helpful to perform the experiment.	C	53	32	16
	P	78	15	8

[1] C = Chemistry; P = Physics; [2]SA = Strongly agree; A = Agree; N = neutral; D = Disagree; SD = Strongly Disagree

Table 3 Reasons why laboratory work is an integral part of a degree course

Statement	Chemistry %	Physics %
A. [Subject] is a practical subject	64	45
B. Experiments illustrate theory for me	43	64
C. Experimental work allows me to test out ideas	12	18
D. Experiments assist me to plan and organise	5	8
E. New discoveries are made by means of experiments	38	42
F. Experimental skills can be gained in the laboratory	68	57
G. Experimental work allows me to think about [subject]	37	48
H. Experimental work makes [subject] more enjoyable for me	32	19

Table 4 Why was a particular experiment useful or enjoyable?

Theme	Chemistry comments (% of 140)	Physics comments (% of 145)
Helped understanding of coursework		24
It was spectacular	21	
It was interesting	19	19
It was easy to see reaction	19	
It was new/different	14	
Easy to understand	8	12
Getting to understand how equipment worked		12
It worked		8
I could work independently		7
TOTAL	80	82

Table 5 What your chosen experiment easy or challenging?

Theme	Chemistry comments (% of 121)	Physics comments (% of 126)
Easy	50	25
In the middle	21	33
Challenging	12	27
TOTAL	83	85

Students were next presented with eight reasons why laboratory work could be considered essential to an undergraduate degree, and were then asked to select the three they felt were the most important. Table 3 shows the results for this question.

Again, there is broad agreement between the groups. The most popular reasons for including labs related to their purpose and the experience they offered to the students. Both groups also agreed that labs do not enhance their ability to plan and organise.

The remaining questions in the survey were expressed in a free-text style. Students were first asked to consider the experiment which they felt to have been the most useful or enjoyable. They were asked: 'What was it about that experiment that made it useful or enjoyable?' The most common responses, as determined by a general inductive approach (Thomas 2006), are summarised

Table 6 What did your experiment teach you?

Theme	Chemistry comments (% of 93)	Physics comments (% of 116)
Intended lab outcomes	42	30
Practical lab skills	37	19
Consolidated course theory	14	10
How to use equipment		14
That chemistry is fun	7	
TOTAL	100	73

Table 7 Which skills have been improved?

Theme	Chemistry comments (% of 73)	Physics comments (% of 96)
Lab skills	81	53
Planning/time management	6	
Teamwork	4	10
Communication	4	9
Understanding of theory		6
Report writing		5
Patience		4
TOTAL	95	87

Table 8 What would you change to improve the laboratory learning experience?

Theme	Chemistry comments (% of 92)	Physics comments (% of 67)
Clearer/better instructions	23	13
Stronger links between theory and labs	17	10
Have more helpful/approachable demons.	12	13
Nothing	9	5
Demonstrations on using equipment		9
Make sure equipment works		9
Wider variety of experiments	7	
Freedom to plan experiments		5
TOTAL	68	64

in Table 4. The same method was used to summarise responses to the subsequent questions.

Students were then asked to consider whether they felt their chosen experiment was easy or challenging (Table 5). Whilst there was a wide spread in the physics responses, the majority of chemistry students clearly preferred the easier experiments.

The next part asked students to say what they felt the experiment had taught them (Table 6). Here, the same themes cropped up regularly in both groups. In each case, the groups felt that they learned the intended outcomes from the experiment, but that they also acquired practical skills and course knowledge. This is in line with their responses given in Table 2.

Finally, relating to this experiment, the students were asked to consider which skills they felt had been improved by carrying out the experiment (Table 7). The clear winner here was laboratory skills, which is perhaps not surprising.

The final question in the survey asked students to put themselves in the position of the laboratory organiser. What would they change if they were in charge next year to improve the laboratory experience? This question elicited a wide range of responses, hence the relatively lower totals in Table 8. There were, though, recurring themes. Clearer instructions were felt to be important, as was strengthening the links between their coursework and the work carried out in the laboratory. Evident in Table 2, both groups had already expressed a belief that this connection was strong – that they wished it to be stronger still highlights the great importance they place on this aspect of their laboratory experience.

Conclusions

In general students are happy with their experiences in their laboratory.

In answering the free-text questions, students often raised similar issues, despite the fact that they were reporting on very different experiments. In particular, students prefer laboratories that are fun, interesting or exciting and which help them to understand the course theory. About as many students found the practical sessions to be easy as found them to be neutral and only slightly fewer found them to be challenging, though here there was some difference between the disciplines. Most students said that the laboratories taught them to understand the theory; bearing in mind how many considered this to be the mark of a good laboratory, this is not surprising, but most groups also felt they gained practical, experimental or laboratory skills. They also listed practical, experimental and laboratory skills as those that had improved and many also mentioned that they had improved their teamwork or group work.

When it came to areas which they felt would need to be changed if they were in charge, the main concerns focused on the support they received in the laboratories, both in terms of notes and demonstrators.

The aim of this study was to compare the attitudes to their lab experience of students in two science subjects. The picture that emerged has been found to be broadly consistent across those disciplines. Laboratory learning is greatly appreciated by students. It is a means for them to develop their knowledge and skills-base. Many of the benefits which the students report to have gained are in line with the aims set out by the AAPT for practical teaching. This study, then, suggests that laboratory teaching in both subjects is meeting its goals and providing a valuable contribution to the education of the students.

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