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Learners' Perspectives on Pure Science Content in Vocational Degree Programs: Chemistry for Pharmacists

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ABSTRACT

The objective of this study was to enquire how the chemistry experience of pharmacy students can be enhanced and how the virtual learning environment (VLE) for chemistry-related pharmacy modules might be improved. All Master of Pharmacy students at the University of Portsmouth United Kingdom were asked to complete a project-designed online questionnaire. Data from University course module feedback questionnaires were also analyzed. Qualitative and quantitative analyses were performed, using appropriate statistical evaluation. Pre-university chemistry was not correlated with current perceived relevance, difficulty, or workload ($p>0.05$). The latter two were positively correlated ($p=0.003$). Students realized their study of chemistry was important (89%). Chemistry- and biology-related areas were rated equally enjoyable ($p>0.05$), but less than pharmacy practice areas ($p<0.0001$). Students' preferred choices for VLE development were video lectures > VLE quizzes > audio content. Keeping chemistry content relevant on pharmacy programs is important. Strategies for improving learning through extended use of the VLE have been identified.

KEY WORDS: pharmacy, chemistry, Master of Pharmacy, higher education, virtual learning environment

INTRODUCTION

For a number of years, there have been concerns regarding the relevance of teaching chemistry to undergraduate pharmacy students (Alsharif et al., 1999; Faruk Khan et al., 2011; Roche et al., 2000; Roche and Alsharif, 2002). The International Pharmaceutical Federation state "Basic (first degree) education programs should provide pharmacy students and graduates with a sound and balanced grounding in the natural, pharmaceutical, and health-care sciences that provide the essential foundation for pharmacy practice in a multi-professional health-care delivery environment" (Prescott et al., 2014. p. 2). In the United Kingdom (UK), over the past decade, the General Pharmaceutical Council, the pharmacy independent regulator, has placed greater emphasis on clinical and practice-based subjects, with more fundamental science-based subjects being increasingly integrated (General Pharmaceutical Council, 2014; Jesson et al., 2006). Anecdotally, student engagement and satisfaction with more chemistry-related areas of the Master of Pharmacy (MPharm) curriculum sometimes appears to be lower than for professional practice elements. If true, this might be due to a combination of factors, such as not being able to appreciate underlying principles in pharmaceutical science, finding chemistry difficult or having had a negative past experience of the subject.

The aim of this paper was to gain MPharm students' perspectives into how they thought their chemistry experience could be enhanced, and how the virtual learning environment (VLE; also known as learning management system) for chemistry-related pharmacy modules could be improved. Pre-university chemistry experiences and current perceptions were also investigated. These data should provide a useful resource for educators in pharmacy to improve chemistry-related learning experiences and to make them relevant, engaging, and enjoyable for students. Research outcomes should be used in conjunction with evidence-based practices that have emerged from numerous meta-study analyses, which link teaching and learning approaches to achievement (Hattie, 2009).

METHODOLOGY

The research was carried out in accordance with the procedures outlined by the University of Portsmouth Research Ethics Committee.

Main Questionnaire

An online questionnaire (Survey Planet) consisting of 20 questions (different types; Table 1) was formulated for all students (years 1-4) across the MPharm course at the University of Portsmouth, the UK. The online design was thought to maximize the return and allow time for more considered responses. The project was undertaken in the form of an MPharm 4th-year project. Students were separately emailed the weblink and asked to take part in the survey through a blind bcc: Opening email stating:

I am a 4th-year pharmacy student carrying out a chemistry education-based project looking at "How the chemistry experience of pharmacy undergraduate students can be

Table 1: Main questionnaire questions and answer choices

Question No.	Question/answers
1	Which year of Pharmacy are you studying in? (1-4th)
2	Which devices do you have? (Please tick the ones that apply to you) [Mobile] [Laptop/netbook] [Tablet] [I do not own any devices] [Other (please specify)]
3	Concerning Q2, which devices do you use to access Moodle? [blank]
4	What A/AS-level chemistry grade did you achieve? [blank]
5	What syllabus board did you study A/AS-level chemistry? Please tick. [OCR (standard OCR)] [OCR (Salters syllabus)] [Edexcel (standard)] [Edexcel (Nuffield)] [AQA] [WJEC] [CCEA (Northern Ireland)] [Scottish Qualification Authority (SQA)] [Cambridge International Examinations (CIE, International students)] [International Baccalaureate] [Other (please specify)]
6	Approximately, how many lab experiments did you do on your A/AS-level chemistry course?[0] [1] [2] [3]….[29] [30]
7	Is the study of chemistry important for a pharmacist? [Yes] [No]
8	If Yes to Q7, in what way? [blank]
9	Of the units you have so far started or completed, please rank the following units in order of your enjoyment of them (1-favorite, to 6-least favorite, for your year): (1st years [Pharmaceutical chemistry] [Introduction to formulation] [Introduction to neuroscience and pharmacology] [Cells to systems] [Developing life-long learning for pharmacy] [Introduction to pharmacy practice])) 2nd years [Drug development and formulation] [Neurosciences, endocrine, and gastrointestinal pharmacology and therapeutics] [Immunology and microbiology in health and disease] [respiratory, renal and cardiovascular pharmacology, and therapeutics] [Medicines patients and public health]) (3rd years [Pharmacology and therapeutics 3] [Pharmaceutical formulation] [Clinical pharmacy and secondary care] [Natural products a source of medicines] [Community and primary care pharmacy] [Pharmacy research methods]) (4th year [Design and advanced delivery of drugs] [Pharmacy project] [Medicines management in practice] [Pharmacology and therapeutics 4])
10	What chemistry topics that you have studied so far on the MPharm do/did you find the least interesting? [blank]
11	Please mark the following statements with 1-strongly agree, 2-agree, 3-neutral, 4-disagree, and 5-strongly disagree: A: In chemistry-related units, the workload is greater than in other units [1-5]; B: There should be more chemistry-related practicals[1] [2] [3] [4] [5]; C: I find chemistry-related units difficult [1-5]; D: I do not see the point in studying chemistry on an MPharm degree [1-5]
12	Rank the following ideas with 1 as top and 10 as least favorite choice: Website of some sort linked to Moodle; More links on Moodle with YouTube clips showing lab practicals; Help from students from previous years; Blog for students to ask each other questions about chemistry-related course content; Chat rooms on Moodle; Quizzes with questions and answers on Moodle; Pre-lecture quiz/pre-lecture recap of previous lecture; Sum-up of the lecture with a few questions; Short audio clips on Moodle with recap points of the lecture/areas people found difficult identified by students emailing lecturers; Complete videos of lectures on Moodle (1-10 sequence for each)
13	Please explain your preferred choice in Q12? (blank)
14	What are your opinions on lab classes? Please tick the most relevant boxes that apply to you. Chemistry-related practicals… (give a better learning experience than just lectures) (are boring) (are just about right) (would be better replaced with lab technique videos) (are difficult) (are rushed) (get me stressed)
15	Which e-learning resources would aid your learning in chemistry? (blank)
16	If videos of laboratory techniques were uploaded to Moodle, which topics/techniques would you like to see? (Please name a few) (blank)
17	Excluding practicals, would you prefer to: (A: Have all/majority of lectures as video lectures where you can download/watch at your own pace and convenience?) (B: follow a more "traditional" style of learning [i.e., coming to lectures]?)
18	Tick the following statement regarding the use of turning point that is most relevant to you… (A: It should be used more) (B: It's annoying) (C: It doesn't help me learn) (D: It's a useful tool for checking my understanding)
19	Students sometimes say they "want more feedback." If this applies to you, what specifically would be useful? (blank)
20	Any other comments/suggestions? (blank)

enhanced" and "How Moodle can be improved for chemistry-related modules." This questionnaire has been designed to find out about the way you perceive how chemistry is taught and views on some ideas. Answers provided will be anonymous and treated confidentially.

As an incentive, a chance to win Amazon vouchers (£20) was offered, provided email addresses were supplied. The questionnaire was made available to students between December 2013 and January 2014. Responding students were allocated numbers so that responses to different questions could be cross-matched/compared. Interviews and the thoughts of lecturers were not investigated in this preliminary study. Statistics were performed using one-way ANOVA (conditions for parametric tests were satisfied - independence, normality, and homogeneity of variance) together with Tukey - *post hoc* testing (α=0.05). Where correlational analysis was required, the Spearman rank correlation (r_s, ordinal, ranked data) was used. Student questionnaires were analyzed using SPSS (Version 22, IBM, NY, USA). Q numbers throughout the text refer to question numbers in this main questionnaire.

The questionnaire generated 122 student responses: 23.9% of the possible 510 total (Q1; Table 2). Progressively higher responses were obtained from each successive year group (e.g. 13% and 41% for years 1 and 4; Table 2).

Formal Feedback Surveys

This university collects student feedback surveys from students on all study units across the university on all its courses to provide formal evaluation (in addition to those data that individual lecturers may collect for their own evaluation). A traffic light system is used as a quality symbol to highlight whether the mean value in any of the performance indicators/responses to questions (Table 3) is below the quality to guideline (red), within the range of tolerance (amber) or within the quality guideline (green). Here, in addition to the "main questionnaire" (Table 1), student enjoyment scores were also extracted from the completed student feedback surveys relating to all pharmacy units being studied on each of the four MPharm degree years (dated April 2013). Some unit titles and content were different to that of the main questionnaire dataset (Table 1) due to the course being mid-way through a period of "integration" to start to address separation of chemistry, biology, and pharmacy practice areas. Statistics were carried out using one-way ANOVA and Tukey - *post hoc* testing (α=0.05; GraphPad Prism Version 6, GraphPad); * $p<0.05$, ** $p<0.01$, *** $p<0.001$, **** $p<0.0001$.

Table 2: Main questionnaire responses by student year

Question No.	Questionnaire statement
1	The unit makes a positive contribution to my overall course
2	I am clear about what I need to do to be successful in this unit
3	Lecturers are good at explaining things on this unit
4	Lecturers make this unit interesting
5	Lecturers are enthusiastic about what they are teaching on this unit
6	Lecturers' use of VLE (Moodle) helped me to learn
7	I am able to communicate with lecturers teaching on this unit when I need to
8	The workload for this unit is manageable
9	Assessment arrangements and marking criteria are fair
10	I have had opportunities to get feedback on my work during this unit.
11	Feedback on my work during this unit helped me clarify things I do not understand
12	The teaching rooms, laboratories, studios, or distance learning materials are of a good quality
13	I enjoyed this unit
14	Overall I am satisfied with this unit

VLE: Virtual learning environment

Table 3: Questions in the formal feedback survey (1=strongly disagree; 2=disagree; 3=neither agree nor disagree; 4=agree; 5=strongly agree)

Student year	Number of students who answered the questionnaire and (%)	Total number of students per year	% of students who answered the questionnaire
1	19 (13)	150	16
2	17 (14)	120	14
3	33 (30)	109	27
4	53 (41)	131	43
Total	122 (24)	510	100

RESULTS AND DISCUSSION

Previous Chemistry Experience

The first enquiry of the data (main questionnaire) concerned students' background education/experiences in chemistry before starting the MPharm. The modal average was General Certificate of Education Advanced/Advanced Subsidiary Level (GCE A/AS-level; approximately equivalent to the Advanced Placement in the United States of America) grade B (range A-E). Although the spread included a fairly large positive skew ("right tail"), including a minor component (6%) who had not studied the subject at this level (Table 4; Access to Higher Education (HE) courses are designed for students wishing to study for a degree, but whom do not have the usual university entry qualifications). The A/AS-level chemistry qualifications were awarded by a range of examination boards (Table 5); these data were recorded to inquire whether different syllabi might account for variations in the number of laboratory practical classes previously undertaken (and hence differences in currently observed laboratory competencies). Rather than checking the syllabi directly, students were asked to estimate the number of laboratory classes they thought they had

Table 4: Pre-university qualification grades in chemistry (Q4)

A/AS-level chemistry grade	Number of students
A*	1
A	13
B	46
C	36
D	12
Access to HE course	7
Did not study chemistry	7
Total	122

A*: 90, A: 80, B: 70, C: 60, D: 50, E: 40, F (Cambridge IGCSE only): 30, G (Cambridge IGCSE only): 20

Table 5: Examination boards awarding A/AS-level chemistry studied by MPharm students before university (Q5)

Syllabus/exam board	Number of students
OCR-standard	38
OCR-Salters	17
Edexcel-standard	10
Edexcel-Nuffield	8
AQA	27
WJEC	3
CCEA (Northern Ireland)	0
SQA	0
CIE	2
International Baccalaureate	2
Other	15
Total	122

SQA: Scottish qualifications authority, CIE: Cambridge International Examinations

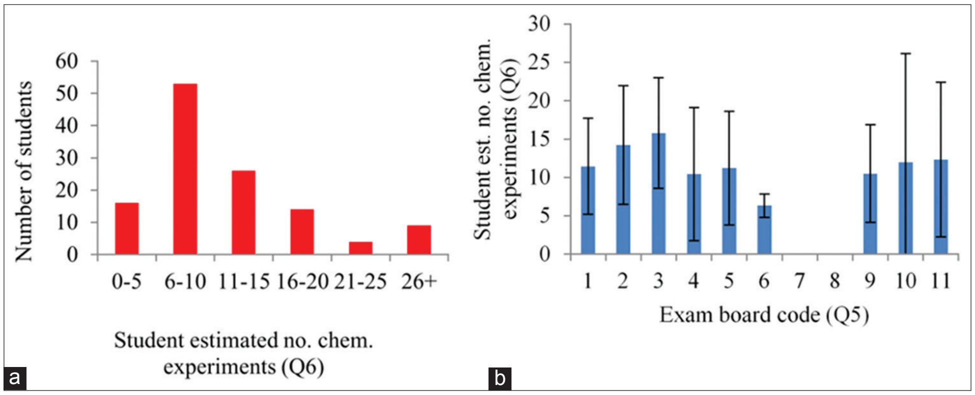

Figure 1: Student estimated number of chemistry laboratory experiments (a) performed during GCE A/AS-levels (Q6), and (b) compared to exam board/syllabus studied (Q5; exam board codes: 1-11=top to bottom, Table 5)

attended during their A/AS-level course (Figure 1a). Again, there was quite a range of responses (mean 12±7), although no significant difference between number of experiments and exam board/syllabus were observed (ANOVA, F=0.823, p=0.584; Figure 1b). Four students had not undertaken any experiments, three of whom had not completed A-levels (including 1 Access student).

Perceived Importance of Chemistry for Pharmacy Students

When asked whether the study of chemistry is important for pharmacy students (Q7), the majority of replies were Yes (N=108, 89%), in agreement with Prescott et al., (47.2% chemistry very important, 42.9% important) (Prescott et al., 2014). The reasons stated for this (Q8) broadly fitted into the following categories: Understanding the mode of drug action and how they work in the body (N=33); important for understanding chemical reactions, properties, and interactions (N=24); fundamental to the degree (N=23); not answered (N=15); useful for industry (N=11); not important (N=8); for drug formulation (N=4); for calculations (N=2); and, an appreciation is needed, but not at such depth (N=2). Hence, clearly meaningful connections of chemistry to pharmacy are seen as being very important.

Enjoyment of Chemistry Content

The units of the MPharm course were classified, by the authors, as being either chemistry (1, Chem), biology (2, Biol), pharmacy practice (3, Pharm Pract), or other (4; e.g. study skills, and also the MPharm project due to large subject type variations). Thus, the classification coding for year 1 = (1,1,2,2,4,3) year 2 = (1,2,2,2,3), year 3 = (2,1,3,1,3,4) and year 4 = (1,4,3,2) for the, respectively, listed units in Table 1 (Q9). The "enjoyment scores" (1 = most favorite, 6 = least favorite; multiple values allowed; Q9, Table 1) were pooled for each of the subject-classified units (not 4, "other") and % subject enjoyment scores were calculated for each student. For example, if only year 4 data were provided and the input for Q9 = (1,6,6,6), the % chemistry enjoyment score = 100%. The data were not normalized with respect to the ratio of subject teaching, although this was approximately even for most answer combinations. Quite a few students (N=52), not counting those from year 1, only rated their current study year, and so the score was only based on the provided data. The mean % enjoyment scores for Chem, Biol, and Pharm Pract subjects were 23±13, 41±16, and 36±15 (*N*=121), respectively, a significant difference (ANOVA, F=48.005, p=3.305-10^{-19}) between Chem and Biol, and Chem and Pharm Pract (p<0.001) was found, although no difference existed between Biol and Pharm Pract (p=0.07). When the subject scores are plotted for each student (Figure 2), quite a range in individual preference can be observed.

To investigate these preferences further, enjoyment scores for Chem, Biol, and Pharm Pract were extracted from the formal unit feedback surveys (Figure 3; for questions, see Table 3) and an ANOVA performed (F=22.46, p<0.0001). As with the main questionnaire (Table 1), the enjoyment score for Chem (3.52±0.93, N=253) was lower than for Pharm Pract (4.06±0.74, N=210; p<0.0001; Table 6), although not between Chem and Biol (3.70±0.91, N=241, p>0.05) and a difference between Biol and Pharm Pract was also found with these data (p<0.0001). The formal feedback responses also highlight that while these differences were seen, students scored a mean of 3.5/5 for Chem, mid-way between the answers of neutral (3) and agree (4) to the statement "I have found the learning activities enjoyable (on this unit)." From these data, it would seem therefore that student enjoyment of chemistry units lags behind pharmacy practice, although was comparable to that in biology-based units. This trend was typical of many of the other performance indicators on the formal feedback survey, such as perceived positive contribution, interesting and enthusiastic lecturers, overall satisfaction and others (Figure 3 and Table 6). This might be due to the perceived direct relevance of pharmacy practice for their future careers.

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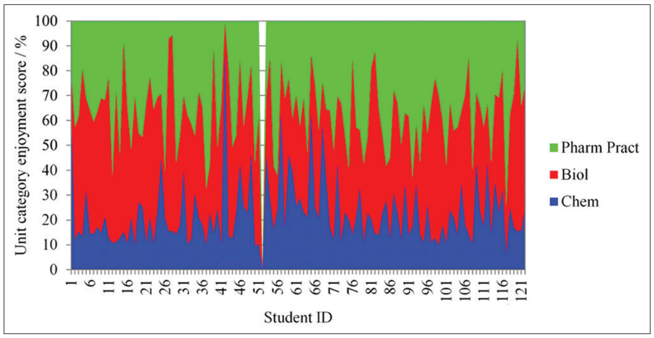

Figure 2: Student enjoyment of chemistry, biology and pharmacy practice-centered course units (Q9)

Student Perceived Difficulty

The responses to Q11 of the main questionnaire provided an overview and some interesting insights: Importantly, chemistry units were seen to be quite difficult (although the workload was not too much of a burden), more chemistry practical lessons were desired and, again (see Q7, 8; Table 1), the importance of chemistry for pharmacy was emphasized (Figure 4). Positive correlations were found between perceived difficulty and "seeing no point" in pharmacy students studying chemistry (r_s=0.297, p=0.001), and between difficulty and

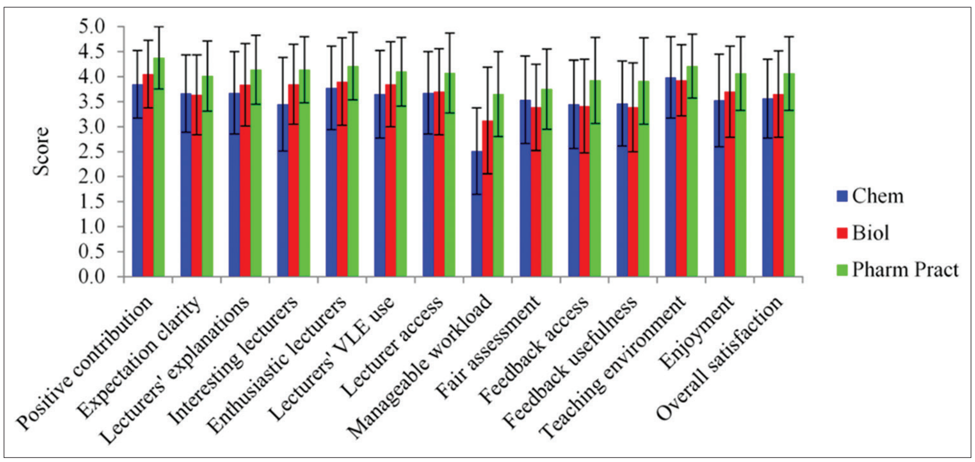

Figure 3: Student responses from formal feedback surveys averaged per unit subject area (N=39-87, 35-67%, depending on question; Apr 2013)

Table 6: Statistical differences in formal feedback data averaged per subject area (Figure 3)

Formal feedback survey component	Subject comparison significance		
	Chem and Biol	Chem and Pharm Pract	Biol and Pharm Pract
Positive contribution	**	****	****
Expectation clarity	NS	****	****
Lecturers' explanations	NS	****	***
Interesting lecturers	****	****	***
Enthusiastic lecturers	NS	****	***
Lecturers' VLE use	*	****	**
Lecturer access	NS	****	****
Manageable workload	****	****	****
Fair assessment	NS	*	****
Feedback access	NS	****	****
Feedback usefulness	NS	****	****
Teaching environment	NS	**	****
Enjoyment;	NS	****	****
Overall satisfaction	NS	****	****

NS: Not statistically different (p>0.05), *p<0.05, **p<0.01, ***p<0.001, ****p<0.0001 workload (r_s=0.271, p=0.003). A negative correlation existed between the desire for more laboratory practical sessions and seeing no point to the study of chemistry (r_s=−0.195, p=0.031); no correlations were found between any of these four responses (Q11) and pre-university chemistry experience (Q4) (p>0.05).

Practical Classes

Regarding chemistry practical classes, students were asked to select from one or more from the words or phrases listed in Table 1 (Q14). The responses (more than one permitted per student) were: "Give a better experience than just lectures" (N=70; 57%), "stressful" (N=46; 38%), "rushed" (N=40; 33%), "just about right" (N=22; 18%), "difficult" (N=19; 16%), "boring" (N=15; 12%), and "would be better replaced with laboratory technique videos" (N=10; 8%). The latter category overlapped with "stressed" in 60% of cases; "just about right" did not overlap with "rushed" or "stressed" in 77% of cases. The level of stress, which is known to have a major influence on learning ability (Stokes and Whiteside, 1984), might be associated with the fact that laboratory sessions are usually assessed (summative assessment), although information/guidance notes are presented to students well ahead of the sessions. The practicalities of performing more laboratory-based learning, possibly with less formal assessment, clearly need to be explored. The benefits of active and experiential learning are well documented as being best-practice (Chickering and Gamson, 1987).

Audience-response Systems

In addition to laboratory practical sessions, audience-response systems ("clickers") used in lectures provide a convenient method for promoting passive to active learners (Barth-Cohen et al., 2015; Cotes and Cotua, 2014). Turning point has been used for a number of years on the MPharm course. Student views (Q18) concerning the use these devices were next investigated (Figure 5). Audience response systems are therefore clearly liked by the majority students who indicate that they help with their learning, especially when used as a formative assessment (Figure 5). More widespread use of this technology is also requested by students. Interestingly, the majority of students who said turning point was "annoying" or "does not help me learn," were 4th year students (80% and 82%, respectively); combined, these unfavorable scores represent 54% of final year students.

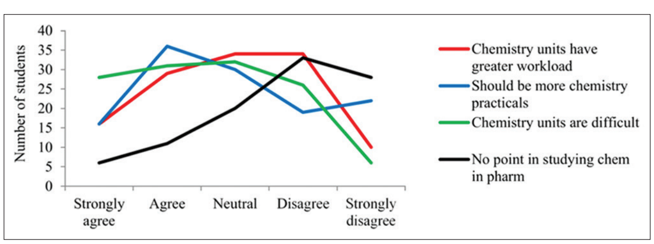

Figure 4: Student views concerning chemistry in relation to other units studied on the course (Q11)

How Can the VLE for Chemistry-related Modules for Pharmacy Students be Improved?

Technology continues to expand rapidly into the area of education. The VLE provides the obvious technology platform for MPharm students to continue their learning beyond the Lecture Theater and laboratory. Moodle has been used for a number of years at the University of Portsmouth and staff members are continually learning how to best incorporate it into their teaching through blended learning (Bonk and Graham, 2006). It was considered useful to survey the MPharm students to see which devices they are currently using generally (Table 7) and to access Moodle (Figure 6). Clearly, laptops and mobile (cell) phones are the main devices currently being used. For those students with laptops and phones, 51% used both devices to access Moodle. These results are useful in considering how the VLE might be used and what constraints and compatibility issues might be important. For example, content with pull-down menus would be inappropriate on a scrolling screen.

Q12 focused on ways in which MPharm students thought the VLE could be improved (Figure 7). Video lectures (type not specified) was the most frequent student first choice (N=50), followed by audio clips (N=39; see Table 1; Q12),

Table 7: Number of MPharm students using various electronic viewing devices (Q2)

Device	Type	Number of students using device
Desktop Microsoft PC	Owned by student	8
	University owned	15
Desktop Macintosh	Owned by student	20
	University owned	0
Laptop	Owned by student	95
	University owned	7
Netbook		2
Tablet	Apple	29
	Blackberry	1
	Microsoft	2
	Samsung	4
	Kindle/Kindle Fire	4
	ASUS/Nexus 7/Google	4
	Other	1
	Do not use	9
Mobile (cell) phone	iPhone	53
	Blackberry	8
	Nokia	4
	LG	0
	Samsung	39
	HTC	17
	Sony	4
	Other	2
	Do not use	0
Other		5

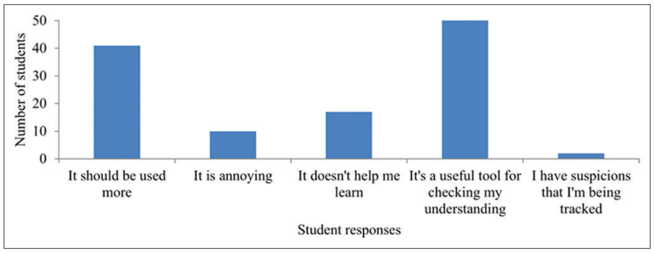

Figure 5: Student views concerning the use of turning point (Q18)

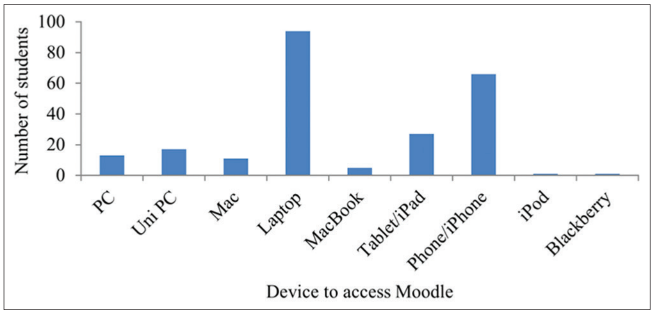

Figure 6: Number of MPharm students using various electronic devices to access Moodle (Q3)

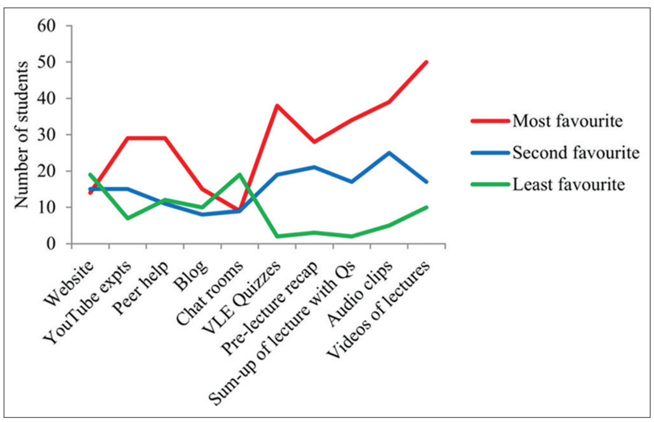

Figure 7: Student preferences to staff/author suggestions for enhancing the chemistry VLE (Q12)

and Moodle quizzes (N=38). The reasons for the student's most favorite choice were categorized as (Q13): Helps with learning and revision (N=77), convenient (N=14), better than lectures, e.g., no distractions, interactive, more interesting (N=10), blank (N=7), guidance (from students and lecturers; N=7), feedback (N=3), prefer traditional lectures (N=2), time effective (N=1), and not sure (N=1). Chat rooms were the least favorite option (Figure 7), possibly since these "campus-based" students already have existing peer interactions rather than with learners on fully online courses who can feel disengaged (Savvidou, 2013). The term discussion group rather than chat room, however, may have produced a better score.

Q17 asked whether students would prefer to have all/the majority of lectures as video lectures, with the prompt that students could download/watch at own pace and convenience, or to follow the traditional style of learning (coming to lectures). Interestingly, the results were ca. 50:50 (N=63, 52%; N=59, respectively). On reflection, this was probably a poor question since students may have thought that lectures would be completely removed and replaced with videos without understanding/being told the concept of the flipped lecture, i.e., formal lecture viewed online by students in their own time and the allocated lecture timetabled slot arranged to provide a more interactive session, such as going over the video, asking questions, and having formative assessments (Bergmann and Sams, 2012; Tomory and Waterson, 2015).

CONCLUSIONS

This study aimed to investigate undergraduate pharmacy students' perspectives regarding the importance of their learning of chemistry content and how this might be enhanced by improvements to the VLE. The pre-university chemistry background experience of the students was also investigated to ascertain the extent to which this may be affecting current perceptions. MPharm students had a wide variation in prior chemistry learning, both theoretically and practically, although this appeared to have no impact on student perceived workload, difficulty, and relevance of chemistry in their studies ($p>0.05$). Perceived difficulty and workload were positively correlated ($p=0.003$), however, as were pharmacy students "not seeing the point" of studying chemistry with perceived difficulty ($p=0.001$), suggesting areas for intervention. Most pharmacy students (89%) said studying chemistry was important, especially when the relevance could be easily identified, and were able to provide appropriate reasons for needing to study the subject. Students rated chemistry-related units with the same level of enjoyment as their biology-cantered counterparts ($p>0.05$), although pharmacy practice elements were deemed more enjoyable ($p<0.0001$), presumably due to the perceived direct relevance for their future careers. Pharmacy students welcomed more laboratory practical sessions, although under less stressful conditions, and wider use of audience response systems in lectures (in years 1-3). Students also welcomed more VLE content, which they access mainly through laptops and smart phones, especially in the form of video lectures and formative assessments (quizzes). These provide, respectively, the ability to review content and gauge current learning (feedback), which are in alignment with evidence-based practices (Hattie, 2009). This study represents a snapshot of the student opinions in one pharmacy education school in the UK and clearly the situation may well be different elsewhere (Hall et al., 2015). It is likely, however, that similar problems associated with making pure science subjects relevant to vocational degree programs will be of universal interest.

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