Enhancing the Chemistry Experience of Undergraduate Pharmacy Students

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ABSTRACT

Student engagement and satisfaction with chemistry-related areas, theoretical and practical, on Master of Pharmacy (MPharm) degree courses anecdotally appear to be lower than for professional practice elements. If true, speculation could be made about student perceived relevance, difficulty, disinterest and previous-negative experiences of chemistry, and strategies developed for improvement of these aspects. In this paper, to follow a more scientific approach, we have asked two main questions: How can the chemistry experience of pharmacy undergraduate students be enhanced, and how can the virtual learning environment (VLE) for chemistry-related modules for pharmacy students be improved? Student responses to an online questionnaire (n = 122, 24%; Dec 2013 – Jan 2014) and data from formal unit feedback surveys (n = 39 – 87, 35 – 67%; Apr 2013) from MPharm students (all four years) studying at the University of Portsmouth, UK were confidentially obtained and analysed.

A breakdown of pre-university chemistry qualifications revealed 49% of students had achieved GCE A/AS-level Chemistry at Grade A*, A or B; 6% had undertaken Access Course chemistry study and a further 6% had no chemistry qualification at A/AS-level or equivalent. These qualifications were awarded by a range of examination boards, although these were not correlated with the number of laboratory sessions the students had attended (0 – 30+; $p > 0.05$). MPharm students had a wide variation in prior chemistry learning, although this appeared to have no impact on current 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. Students realised the study of chemistry on their MPharm degree was important (89%), and when asked why, meaningful answers concerning understanding drug action were provided. Students rated chemistry-related units with the same level of enjoyment as their biology-centred 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 to 3). MPharm students access the VLE (Moodle) with a vast array of platforms, and often with multiple devices, potentially raising compatibility issues for course developers. Presented with a choice of mostly technology-based methods in which chemistry teaching could be improved, video lectures were the preferred choice (although not as a replacement for traditional lectures), followed by Moodle quizzes and audio content; chat-rooms and websites were the least preferred.

The results highlight the importance of keeping chemistry (and biology) content relevant in MPharm programmes and reveal strategies suggested by students for improving their learning through extended use of the VLE. These outcomes are in alignment with evidence-based practice approaches.

Keywords: Pharmacy; Chemistry; MPharm; Higher education; Virtual learning environment (VLE)

INTRODUCTION

For a number of years, there have been concerns regarding the relevancy of teaching chemistry to undergraduate pharmacy students [1-4]. The International Pharmaceutical Federation state 'Basic (first degree) education programmes should provide pharmacy students and graduates with a sound and balanced grounding in the natural, pharmaceutical and healthcare sciences that provide the essential foundation for pharmacy practice in a multi-professional healthcare delivery environment' [5]. In the UK, over the past decade, the General Pharmaceutical Council (GPhC), the pharmacy independent regulator, has placed greater emphasis on clinical and practice-based subjects, with more fundamental science-based subjects being increasingly integrated [6,7]. 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; 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 [8].

METHODOLOGY

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, UK. The online design was thought to maximise the return and allow time for more considered responses. The project was undertaken in the form of an MPharm 4th year project (by MKC supervised by JRS). Students were separately emailed the weblink from MKC and asked to take part in the survey *via* 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 enhanced' & '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 (collected by MKC, but not disclosed to JRS). The questionnaire was made available to students Dec 2013 – Jan 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 with Tukey-post hoc testing (α = 0.05) and Spearman rank correlations (SPSS Version 22, IBM, NY, USA).

A separate, but related, dataset was pooled from formal unit feedback surveys across all the MPharm years, dated Apr 2013. Some unit titles and content were different to that of the questionnaire dataset due to the course being mid-way through a period of "integration" to already 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, CA, USA).

Table 1. Questionnaire questions and answer choices

Question No.	Question / Answers
1	Which year of Pharmacy are you studying in? [1st][2nd][3rd][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-favourite, to 6-least favourite, for your year): {1st Years [Pharmaceutical chemistry][Introduction to formulation][Introduction to neuroscience & pharmacology][Cells to systems][Developing life-long learning for pharmacy][Introduction to pharmacy practice]}{2nd Years [Drug development & formulation][Neurosciences, endocrine & gastrointestinal pharmacology & therapeutics][Immunology & microbiology in health and disease][Respiratory, renal & cardiovascular pharmacology & therapeutics][Medicines patients & public health]}{3rd Years [Pharmacology & therapeutics 3][Pharmaceutical formulation][Clinical pharmacy & secondary care][Natural products a source of medicines][Community & primary care pharmacy][Pharmacy research methods]}{4th Year [Design & advanced delivery of drugs][Pharmacy project][Medicines management in practice][Pharmacology & 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 & 5-strongly disagree: A: In chemistry-related units, the workload is greater than in other units [1][2][3][4][5]; B: There should be more chemistry-related practicals [1][2][3][4][5]; C: I find chemistry-related units difficult [1][2][3][4][5]; D: I don't see the point in studying chemistry on an MPharm degree. [1][2][3][4][5]
12	Rank the following ideas with 1 as top and 10 as least favourite 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 to 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 lab 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 TurningPoint 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]

RESULTS AND DISCUSSION

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. The overall response rate was judged sufficient to be a representative sample size.

Table 2. Questionnaire responses by student year

Student year	Number of students who answered the questionnaire (%)	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

Previous chemistry experience

The first enquiry of the data concerned students' background education/experiences in chemistry prior to starting the MPharm. The modal average was General Certificate of Education Advanced/Advanced Subsidiary Level (GCE A/AS-level; *ca.* equiv. Advanced Placement in USA) grade B, 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 3; Access to 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 4); 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 attended during their A/AS-level course (Fig. 1a). Again, there was quite a range of responses (mean 12 ± 7), although there was no correlation with exam board/syllabus ($p > 0.05$; Fig. 1b). Four students had not undertaken any experiments, three of whom hadn't completed A-levels (including 1 Access student).

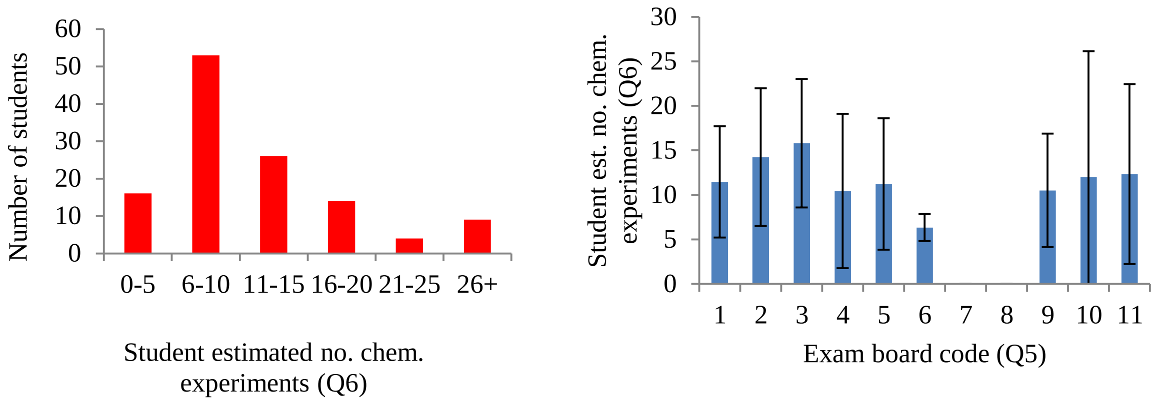
Table 3. Pre-university qualification grades in chemistry (Q4)

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

Table 4. Examination boards awarding A/AS-level chemistry studied by MPharm students before university (Q5)

Syllabus / board	OCR-Standard	OCR-Salters	Edexcel-Standard	Edexcel-Nuffield	AQA	WJEC	CCEA (Northern Ireland)
Number of students	38	17	10	8	27	3	0

Syllabus / board	Scottish Qualifications Authority (SQA)	Cambridge International Examinations (CIE)	International Baccalaureate	Other	Total
Number of students	0	2	2	15	122



(a) **(b)**

Fig. 1. (a) Student estimated number of chemistry laboratory experiments performed during GCE A/AS-levels (Q6); (b) correlation of Q5 and Q6 responses (Q5 codes: 1-7 = top horizontal list, Table 4, 8-11 = lower horizontal list, Table 4)

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) [5]. 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). So, clearly meaningful connections of chemistry to pharmacy are seen as being very important.

Enjoyment and difficulty 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 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 favourite, 6 = least favourite; 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 was provided and the input for Q9 = (1, 6, 6, 6), the %chemistry enjoyment score = 100%. The data was not normalised 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 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 (Fig. 2), quite a range in individual preference can be observed.

To investigate these preferences further, enjoyment scores extracted from the formal unit feedback surveys (Fig. 3). Again, the enjoyment score for Chem was lower than for Pharm Pract ($p = 0.0001$; Table 4), although not between Chem and Biol ($p > 0.05$) and a difference between Biol and Pharm Pract was found with these data ($p < 0.0001$). The formal feedback responses also highlight that whilst 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 that in biology-based units. This might be due to the perceived direct relevance of pharmacy practice for their future careers.

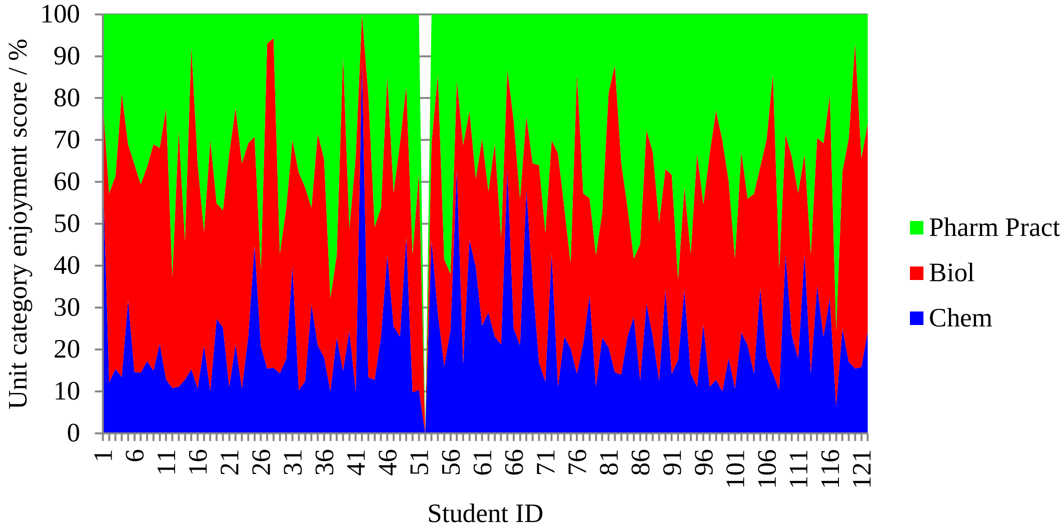


Fig. 2. Student enjoyment of chemistry, biology and pharmacy practice-centred course units (Q9)

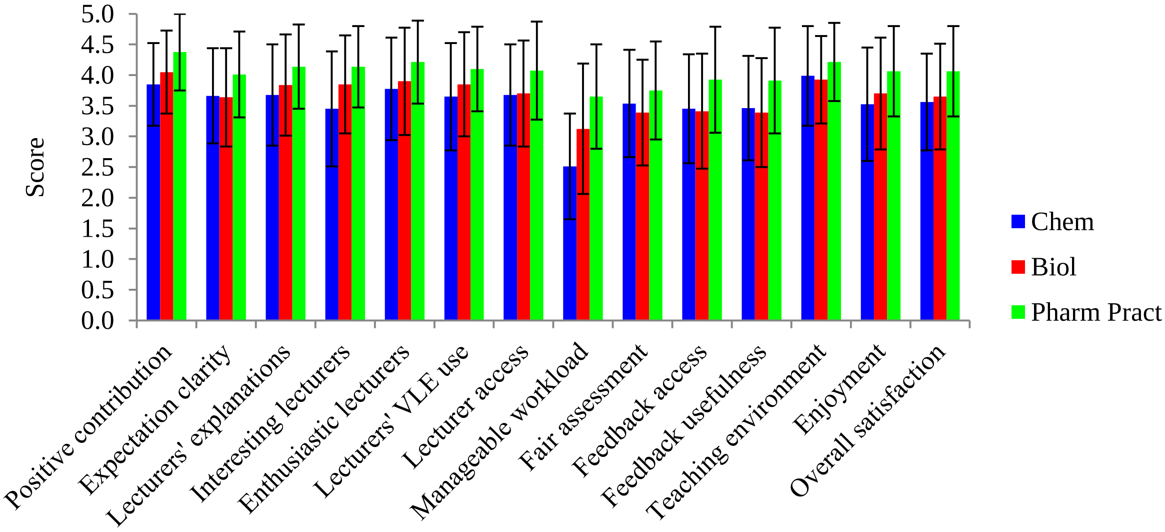


Fig. 3. Student responses from formal feedback surveys averaged per unit subject area (n = 39 – 87, 35 – 67%, depending on question; Apr 2013)

Table 4. Statistical differences in formal feedback data averaged per subject area (Fig. 3); 1 = Chem, 2 = Biol, 3 = Pharm Pract; NS = not statistically different ($p > 0.05$); top row letters are abbreviations from Fig. 3 (left to right).

	PC	EC	LE	IL	EL	VLE	LA	MW	FA	FC	FU	TE	E	OS
1& 2	**	NS	NS	****	NS	*	NS	****	NS	NS	NS	NS	NS	NS
1 & 3	****	****	****	****	****	****	****	****	*	****	****	**	****	****
2 & 3	****	****	***	***	***	**	****	****	****	****	****	****	****	****

The responses to Q11 of the 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), the importance of chemistry for pharmacy was emphasised (Fig. 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 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).

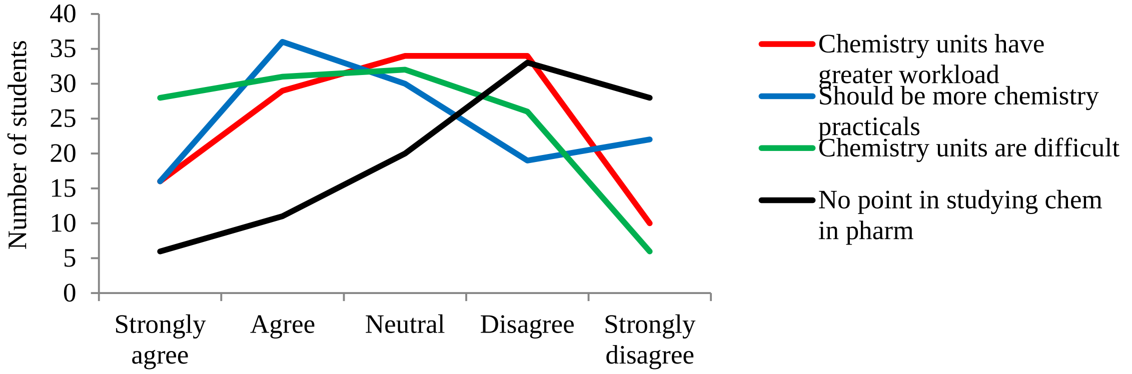


Fig. 4. Student views concerning chemistry in relation to other units studied on the course (Q11)

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%). Video overlapped with stressed in 60% of cases; just about right didn't overlap with rushed or stressed in 77% of cases. The level of stress, which is known to have a major influence on learning ability [9], 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 [10].

In addition to laboratory practical sessions, audience-response systems ('clickers') used in lectures provide a convenient method for promoting passive to active learners [11]. TurningPoint has been used for a number of years on the MPharm course. Student views (Q18) concerning the use these devices were next investigated (Fig. 5).

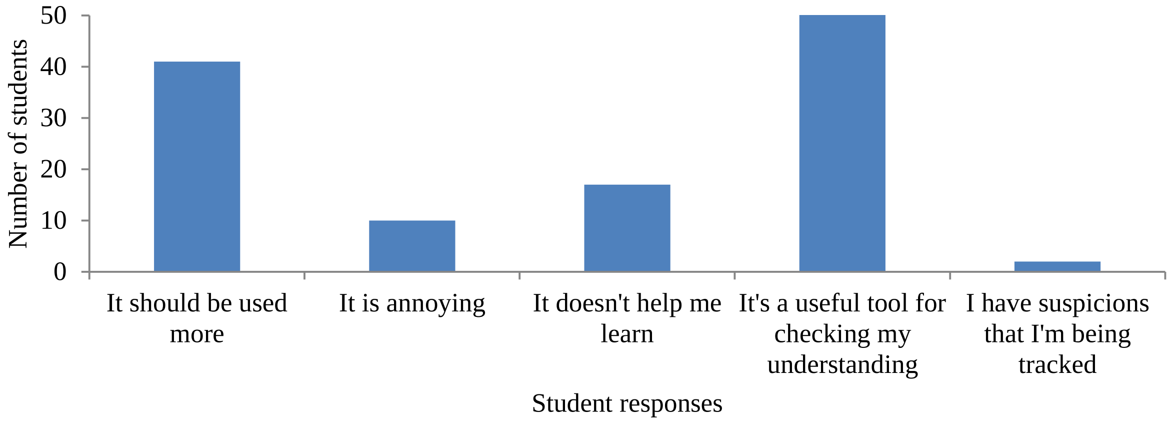


Fig. 5. Student views concerning the use of TurningPoint (Q18)

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 (Fig. 5). More widespread use of this technology is also requested by students. Interestingly, the majority of students who said TurningPoint was ‘annoying’ or ‘doesn’t help me learn’, were fourth year students (80% and 82%, respectively); combined, these unfavourable scores represent 54% of final year students.

How can the VLE for chemistry-related modules for pharmacy students be improved?

Technology continues to expand into the area of education. The VLE provides the obvious technology platform for MPharm students to continue their learning beyond the lecture theatre and laboratory. Moodle has been used for a number of years at the University of Portsmouth and staff are continually learning how to best incorporate it into their teaching *via* blended learning [12]. It was considered useful to survey the MPharm students to see which devices they are currently using generally (Table 5) and to access Moodle (Fig. 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.

Table 5. Number of MPharm students using various electronic viewing devices (Q2); PC = Desktop Microsoft PC; Mac = Desktop Macintosh; NB = Netbook; W = Student’s own device; U = University device; A = Apple; B = Blackberry; M = Microsoft; G = Samsung; K = Kindle / Kindle Fire; S = ASUS / Nexus 7 / Google; O = Other; X = Do not use; I = iPhone; N = Nokia; L = LG; H = HTC; Y = Sony

	PC		**Mac**		**Laptop**		**NB**	**Tablet**							
	W	**U**	**W**	**U**	**W**	**U**		**A**	**B**	**M**	**G**	**K**	**S**	**O**	**X**
Number	8	15	20	0	95	7	2	29	1	2	4	4	4	1	9

	Mobile (Cell) phone									**O**
	I	**B**	**N**	**L**	**G**	**H**	**Y**	**O**	**X**	
Number	53	8	4	0	39	17	4	2	0	5

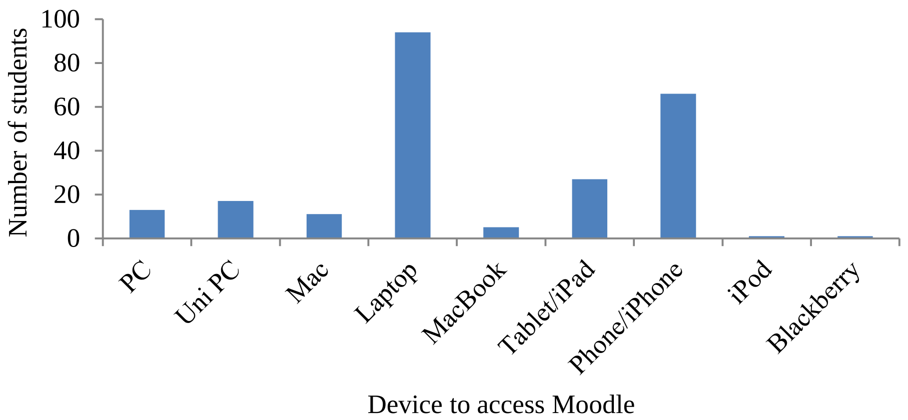


Fig. 6. Number of MPharm students using various electronic devices to access Moodle (Q3)

Q12 focused on ways in which MPharm students thought the VLE could be improved (Fig. 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) and Moodle quizzes (N = 38). The reasons for the student’s most favourite choice were categorised 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 favourite option (Fig. 7), possibly since these “campus-based” students already have existing peer interactions rather than with learners on fully online courses who can feel disengaged [13]. The term discussion group rather than chat room, however, may have produced a better score.

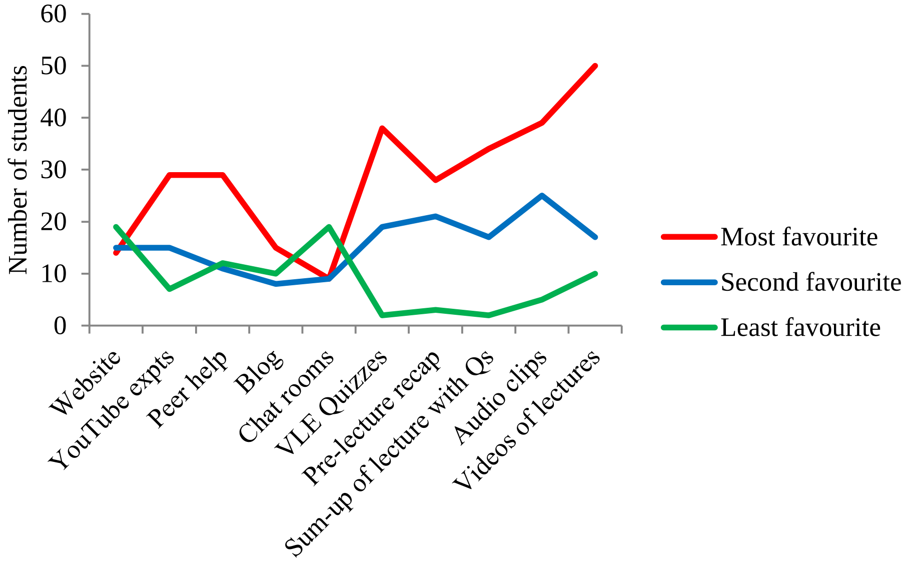


Fig. 7. Student preferences to staff/author suggestions for enhancing the chemistry VLE (Q12)

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 [14].

CONCLUSIONS

This study aimed to investigate undergraduate pharmacy student's 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-centred 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 to 3). Students also welcomed more VLE content, which they access mainly *via* 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 [8].

Since undertaking this study, the use of video lectures (flipped classroom style) and an increased use of Moodle quizzes have been implemented by JRS. A detailed investigation of the effectiveness of the former has been undertaken and will be published shortly.

AUTHORS

James R. Smith is a Senior Research Fellow at University of Portsmouth. He has a BSc(Hons) in Applied Chemistry, PGCE in Post-Compulsory Education and a PhD in Electrochemistry/Polymer Science. His current collaborative research is mainly focused in areas of nanotechnology and targeted drug delivery. He has contributed to over 130 research publications since 1994. He teaches undergraduate pharmacy students and provides training and supervision on PhD research programmes. He is a Fellow of the Higher Education Academy and Fellow of the Royal Microscopical Society. Further details can be found on his website www.jamesrsmith.net. E-mail: james.smith@port.ac.uk (Corresponding author)

Melleisha K. Chungh graduated from University of Portsmouth with an MPharm in 2014. Most of the data in this paper was obtained from her final year project, under the same title as this paper and carried out under the supervision of JRS. She is now undertaking her pre-registration pharmacy year. E-mail: melleisha@me.com

Sara Sadouq and Asarthan Kandiah are MPharm students who completed their final year projects in 2015, again under the supervision of JRS. These projects were focused on the use of video techniques in pharmacy education. They contributed to the writing of this manuscript. E-mails: sara.sadouq@myport.ac.uk, asarthan.kandiah@myport.ac.uk

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