Making Physical Pharmacy Education Meaningful for Pharmacy Students

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Research Article

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Abstract

Objective: The perceptions and satisfaction of pharmacy students with a Fall 2009 Physical Pharmacy Lab focusing on pH and drug properties (e.g. solubility, Ionization, partition coefficient etc..) were studied in order to evaluate if the teaching method was meaningful and effective to the students, and to describe the necessity of incorporating a lab section in Physical Pharmacy course.
Methods: A pre-lab quiz was administered to 109 students before the course and a course evaluation was administered to each student at the conclusion of the course. Students' responses on five variables, namely Satisfaction, Learning and examination, Future alternatives, Overall assessment, and Test improvement were gathered and evaluated using a 5-point Likert scale. Data were analyzed using Excel 2007. To further evaluate if the learning objective had been achieved, the students' lab grades were compared with pre-lab quiz scores.
Results: Overall 4 out of the 5 lab sessions were graded above 3.0 (Good) on a 1-5 scale (5 being Excellent) basis. Regarding future alternative options of the course, the only option with major support (agrees and strongly agree> 50%) was "Practical lab only" (55.41%). The students' understanding on topics related to pH and drug properties was improved by 43% as shown by improvement on test score. The improvements between the pre-lab score and final lab score were statistically significant ($P<0.05$).
Conclusion: This specific laboratory course was found to effectively help students fortify the ideas they learned in classroom and it was welcomed by most of students. The strategy of combining lecture with lab practice proved to be effective and meaningful in physical pharmacy education.

Key words: Physical Pharmacy, laboratory, perception, curriculum, student survey.

Introduction

Pharmaceutical education and curricular guidelines have gone through major changes in the past decade with an increased emphasis on developing critical thinking, problem solving, and professionalism in pharmacy education[1]. It was also specified in Accreditation Council for Pharmacy Education (ACPE) standards and guidelines that the students should gain certain competencies in sciences, such as bioanalysis, chemistry and physical pharmacy, so that they can incorporate them into pharmacy practice[2]. Although some of the areas might be addressed or covered in pre-professional classes, the guidelines still stressed that the majority of these scientific courses should be part of the professional curriculum.

Physical pharmacy/Biophysical pharmacy is one of the key aspects emphasized by ACPE guidelines as it provides critical information on pharmaceutical formulations, such as physicochemical principles of dosage forms, principle of drug delivery of dosage forms, and principle of dosage form stability and drug degradation[2]. It is critical for future pharmacists to understand the science behind dosage form design. Similar topics as acid-base chemistry and relative analytical techniques have been included in other pharmacy schools' curriculum [3 4]. Physical pharmacy is also a challenging course for students. An important contribution factor to cause difficulty may be the manner in which basic science concepts are traditionally taught [5]. Physical pharmacy is typically taught through lecture without any supporting labs or outside application of the material. Extensive prior research indicates that unfamiliar, difficult and abstract material is learned more effectively when the information is meaningful to students compared to rote learning (i.e. students can make connection to existing knowledge and the material is made more "concrete") [6 7]. Therefore pharmacy students shall learn difficult physical pharmacy concepts more effectively through a more meaningful way.

The previous research has focused on different course designs and teaching methods in order to improve the quality of pharmacy education [8-10]. In fact, one effective method to learn basic scientific principles is through laboratory practice, because laboratory practice could be

considered to be part of Problem-based-learning (PBL). Extensive research on PBL has found that students who engage in this approach benefit from gains in factual learning that are equivalent or superior to those of students who engage in traditional forms of instruction [11] [12]. The application of PBL also enables the alignment with Bloom's Taxonomy of Educational Objectives[13]. Bloom's Taxonomy is an order of learning complexes. The key categories of Bloom's Taxonomy are as follows: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation [14]. In the classroom, students were lectured on various scientific ideas and asked to fulfill assignments and pass tests (i.e. Knowledge and Comprehension). But through a properly designed laboratory course, students could apply what they've learned in classroom and obtain hands-on experiences. This allows them to reach higher levels of learning such as Application, Analysis, Synthesis and Evaluation.

Therefore, in order to provide a more meaningful and effective way of teaching physical pharmacy, a mid-west pharmacy school has been providing a 4-credit US Midwestern physical pharmacy course to 2nd year PharmD students. This course focused on physicochemical properties of drug systems with consideration of incompatibilities and stabilization of pharmaceutical dosage forms, and physicochemical properties affecting drug action and drug degradation. This course also requires the pharmacy students to take one credit lab session for physical pharmacy (PHAR 7202 Lab). To our knowledge, not all pharmacy schools in the United States offer this costly physical pharmacy lab.
Thus, the purpose of this study was to investigate students' perception and satisfaction with the Fall 2009 Physical Pharmacy lab section of this course.

Methodology

Sample

109 professional degree students enrolled in a required physical pharmacy course at a US Midwestern school of pharmacy. Students's demographic data can be found in **Table 2**.

Procedures

This investigation was conducted for a one credit laboratory course following physical pharmacy lectures during 2009 fall semester for 109 students in a US Midwestern school of pharmacy. There were 5 different experiments and each one took 3 hours in one afternoon per group and per week. The whole lab session covered 5 week period. A newly constructed teaching lab fully equipped with state-of-art and necessary instruments, such as pH-meter and UV spectrophotometer was provided. Students were divided into groups of 6-8 members in each experiment. Graduate teaching assistants (GTAs) served as instructors for pre-lab lectures and lab guidance. The GTAs meet weekly with principle instructor to discuss the course plan. Students were given a pre-lab test at the orientation of the course and they were required to submit lab reports individually and to attend a post-lab quiz after each experiment. The topics of each experiment corresponded with the topics in physical pharmacy lecture. Since pH, pKa, buffers, solubility, and partition were taught in the lecture. The laboratory session topics and learning objectives were presented as shown in **Table 1**.

Measures

Students' satisfaction was evaluated at the conclusion of the lab through a comprehensive 29-item survey form. Course and instructor evaluations were administered to each student at the end of the lab. The questions rated students' perception of the course and instructors using a 5-point Likert scale at 5=strongly agree (or excellent), 4= agree (or very good), 3=neutral (or good), 2= disagree (or fair) and 1=strongly disagree (or poor)[15]. The evaluation was divided into 4 parts: Satisfaction with individual lab, Assessment of learning and examination, Assessment of future alternatives, and Overall assessment. Questions 1 through 15 were used to evaluate the quality of each lab based on three criteria namely: organization and quality, knowledge gained in the lab, and relevance to future career as a pharmacist. Questions 16 through 19 evaluated if the learning objectives was achieved and if the grading of quiz and lab report was fair. Questions 20 trough 23 discussed different scenario of the future physical pharmacy lab session, including practical lab only, virtual lab only, combination of both practical and virtual lab, and no lab (lecture only). Questions 24 and 25 focused on overall assessment of the quality of the labs. Students were allowed to leave their feedbacks on open-ended questions 26 through 29 about their views and suggestions on the lab. Five variables, namely Satisfaction, Learning and examination, Future alternatives, Overall assessment, and Test improvement were evaluated using the above 5-point Likert scale, and data were analyzed using Office Excel 2007.

Table1: Topics of 5 experiments in PHAR 7202 Lab sessions.

Experiments	Content	Leaning objective
Lab1	Graphing and determination of pKa	Apply proper graphing in titration
Lab2	Buffer capacity and measurement of pH	Prepare proper buffer system using Van Slyke equation
Lab3	Buffers and pharmaceutical formulation	Challenge and determine buffer capacity of artificial human blood
Lab4	pH and drug solubility	Apply Beer-Lambert's law to determine drug solubility
Lab5	pH and drug partition coefficient	Understand the relations between pH and partition coefficient

Table 2: Participant Demographics (n=109)

Variable	No. (%)
Gender	
Male	34 (31)
Female	75 (69)
Age Range*	18-53
Race	
White	83 (76)
Hispanic	2 (2)
Black	6 (6)
Asian/Pacific Islander	9 (8)
American Indian/Alaska Native	1 (1)
RTI**	8 (7)

* The number of specific age range was not obtained
** RTI: Ethnic group not identified

Table 3: Satisfaction with Lab 1 through 5 of PHAR 7202 Lab, % (N=74)

	Poor	Fair	Good	Very good	Excellent	Score
Lab1 organization and quality	10.81	28.38	39.19	20.27	1.35	2.73
Knowledge gained	9.46	37.84	39.19	13.51	0.00	2.57
Relevance to future career	16.26	33.78	33.78	10.81	5.41	2.55
Lab2 organization and quality	2.70	2.70	52.70	27.03	14.86	3.49
Knowledge gained	1.35	12.16	55.41	25.68	5.41	3.22
Relevance to future career	2.70	8.11	55.41	24.32	9.46	3.30
Lab3 organization and quality	5.41	17.57	36.49	35.14	5.41	3.18
Knowledge gained	6.76	18.92	50.00	21.62	2.70	2.95
Relevance to future career	2.70	20.27	48.56	21.62	6.16	3.09
Lab4 organization and quality	5.41	16.22	45.95	27.03	5.41	3.11
Knowledge gained	1.35	18.92	58.11	18.92	2.70	3.03
Relevance to future career	1.35	14.86	51.35	22.97	9.46	3.24
Lab5 organization and quality	2.70	12.16	36.49	31.08	17.57	3.49
Knowledge gained	0.00	13.51	44.59	29.73	12.16	3.41
Relevance to future career	2.70	14.86	44.59	24.32	13.51	3.31

Discussion and Conclusion:

In the evaluation, the students were overall satisfied with Fall 2009 physical pharmacy Lab organization and quality. Some of the written comments submitted by the students on the evaluation included: "Although it was time consuming I felt the labs were beneficial for pharmacy practice in the future." "I liked the way the lab was set up where the instructors did an overview of the lab, explained the procedure, and very helpful during the procedure."

Although most labs were graded at least "Good", some improvements could still be made. Lab 1 was found to be the lowest scored labs among the five (See **Table 3**). In written comments (Question 27), 23 students (63.9% of total respondents) referred to lab 1 as the "least useful part" of physical pharmacy Lab. The reasons, according to students' feedback, was they've already learned the relevant lab technique (such as titration) in their required pre-pharm courses, and most of them was using software for data analysis, therefore hand-graphing was not helpful at all. As a result of this survey, the topic of hand-graphing and titration should be removed in future physical pharmacy Lab.

Table 4: Assessment of learning and examination of PHAR 7202 Lab, % (N=74)

	SD	D	N	A	SA	Score
Labs enabled me to determine more effectively of pH of pharmaceutical drug products	4.05	6.76	24.32	56.76	8.11	3.58
Labs enabled me to better understand the practical role and importance of pH in pharmaceutical formulations	2.70	5.41	20.27	59.46	12.16	3.73
Grading of lab reports were fair	1.35	2.70	22.97	41.89	31.08	3.99
Grading of quizzes were fair	0.00	8.11	36.49	31.08	24.32	3.72

Note: SD= Strongly disagree, D= Disagree, N= Neutral, A= Agree, SA= Strongly agree.

Table 5: Assessment of future alternatives options of PHAR 7202 Lab, % (N=74)

	SD	D	N	A	SA	No res	Score
I prefer practical lab only	10.81	18.92	14.86	31.08	24.32	0.00	3.39
I prefer virtual lab only	24.32	20.27	20.27	24.32	9.46	1.35	2.74
I prefer combination of practical and virtual lab	16.22	18.92	24.32	28.38	10.81	1.35	2.99
I prefer no lab sessions and classroom lecture only	27.93	32.43	12.16	9.46	14.86	1.35	2.47

Note: SD= Strongly disagree, D= Disagree, N= Neutral, A= Agree, SA= Strongly agree, No res=No response.

Table 6: Overall assessment of PHAR 7202 Lab, % (N=74)

	SD	D	N	A	SA	No res	Score
I think the time and resources spent on labs have been worthwhile in consideration of learning achieved	9.46	16.22	29.73	40.54	2.70	1.35	3.11
I found these labs to be useless and should all be canceled and replaced by more classroom lecture time	12.16	41.89	21.62	16.22	5.41	2.70	2.60

Note: SD= Strongly disagree, D= Disagree, N= Neutral, A= Agree, SA= Strongly agree, No res=No response.

Table 7: Recommendation for future experiment topics.

Topic	No. (%)
Reology	3 (60)
Viscosity	1 (20)
Fluorescence	1 (20)

A majority of the students thought the Fall 2009 physical pharmacy Lab was very helpful in better understanding of the topics (mainly pH and buffer) they learned in Physical pharmacy I. For example, in the written feedbacks of the "Most useful part in the lab", 16 students (37.2% of total respondents) mentioned "Obtain hands-on experience on the topics learned", 10 students (23.2% of total respondents) mentioned "Pre-lab lectures and help on calculations helped them better understanding the topic", and 13 students (30.2% of total respondents) mentioned individual lab among the five topics as the most useful part. Although current setting of physical pharmacy Lab served as a good method for students to better understand the concept of pH and buffers, a variety of lab topics were required by the students. In written open-ended questions of the evaluation, students were asked to give recommendation for new laboratory topics (if any), and topics like rheology and viscosity were frequently mentioned by 80% of the total respondents (see **Table 7**). Therefore more topics should be incorporated and designed as part of physical pharmacy Lab instead of solely focused on pH and buffers.

The way of having the physical pharmacy Lab course was somewhat controversial according to the evaluation. "Practical lab only" was shown as the top choice (55%), but still there was 30% of the students strongly disagree or disagree of that idea. Among the alternatives, the combination of the practical lab and virtual lab might worth further investigation. Since there's an increasing demand for pharmacists, many new schools of pharmacy are being established and numerous existing schools of pharmacy are increasing class size[16], it raises the issue of inadequate time and resources for massive application of practical lab sessions. A lot of reports have been discussing the pros and cons of distance education method such as virtual classroom or video/audiotaped lectures [17-20]. However, as a result, the quality of the instruction and the ability of the students to master course outcomes should not be compromised. As it is still under debate, the better strategy might be provide pre-lab lectures and/or some demonstrative labs in virtual labs and keep those important topics which are highly relevant to Physical pharmacy lecture in practical lab format. The alternatives of having no lab but lectures in order to save time and resource might not be a good idea, since a majority of students (62.16% in questions 23 and 54.05% in question 25) strongly disagree or disagree canceling lab as an alternative.

There has been an increased focus on the importance of recognizing students' differences in their learning styles [21]. Pungente et.al. reported that 3 out of 4 learning styles (Convergers, Assimilators, and Accommodators) identified by Kolb's Learning Style Inventory (LSI) exhibited an overall positive response to Problem-Based Learning (PBL) approach [22]. Although there's debate showing students' learning style may change and their participation may decrease in PBL [23], our study showed the learning objective has been achieved after problem-based lab course, as students grades in quiz relating to physical pharmacy concept increased by 43% after lab course. This could be recognized as a "meaningful learning" process because by relating new information gained in the lab session to the knowledge stored in their long-term memories, students find "meaning" in that information. Therefore they learn more effectively.

In this study, a teaching method combining lecture and practice lab in physical pharmacy education was evaluated in Fall 2009. Overall majority of students were satisfied with current lab session and wish to keep the practical lab for better understanding of the concept taught in the lectures and to be able to obtain hands-on experiences necessary for their future career development. Course weaknesses included the lack of variety of the topic, and redundant topics or topics already covered by students' previous course. Despite some flaws, the physical pharmacy Lab helps students to learn physical pharmacy concept in a more meaningful and effective manner. Students' understanding of physical pharmacy concepts was greatly improved by this teaching method. Lab should be kept with continuous improvement in the lab topics. Virtual labs could be

considered as a supplementary teaching method, such as in titration and graphing.

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AUTHORS' CONTRIBUTIONS

Authors contributed equally to all aspects of the study.

PEER REVIEW

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests