An Integrated Approach to Teaching Laboratory Data and Pharmacology of Respiratory Diseases to Pharmacy Students

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Abstract
Laboratory data course has been designed in the Faculty of Pharmacy at Beirut Arab University to build and develop the basic skills needed in the analysis and interpretation of laboratory test results to ultimately ensure safety and effectiveness of the patient's treatment regimen. The aim of this study is to describe and evaluate the impact of a multidisciplinary module integration, customized by pharmacology, laboratory data and pharmacotherapeutics disciplines, in teaching asthma and COPD pharmacotherapy on the third level Beirut Arab University pharmacy students’ knowledge acquisition and satisfaction. Following the completion of an integrated approach, third year pharmacy students (N= 92) were recruited to participate in filling close-ended questionnaire based on 5-point Likert scale. One-sample t-test was conducted in the statistical results of Likert scale. The strength of the relationship between the students' performance (represented by grade point average, GPA) in laboratory data, pharmacology and pharmacotherapeutics was determined using Spearman's Rho Correlation. Statistical analysis of students' evaluation identified a positive feedback on the integrated module, which significantly contributed to their enhanced performance in the subsequent pharmacotherapeutics course. Spearman's Rho coefficient analysis revealed a moderate positive and statistically significant correlation between laboratory data and pharmacotherapeutics GPAs (rs(86)=.38, p<.05). The integrated module was well-appreciated as an effective way of asthma and COPD pharmacotherapy learning by third year pharmacy students. Nevertheless, findings of the present study identified the insufficient allotted time for pharmacology I as a shortcoming of the multidisciplinary integrated module, underscoring an urgent need of fine-tuning of the curriculum. The integrated module was well-appreciated as an effective way of asthma and COPD pharmacotherapy learning by third year pharmacy students. The introduction of laboratory data as an integrative discipline greatly helped the students apply the integrated knowledge in the pharmacotherapeutics course.

Keywords
curriculum, laboratory data, pharmacology, respiratory, integration

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1. INTRODUCTION
The curriculum is a pile of jigsaw puzzle pieces without a picture, unless put together through the implementation of coherent integration (Beane, 1995). Aside from being mandated by accreditation organizations (Canadian Council for Accreditation of Pharmacy Programs, 2018; Accreditation Council for Pharmacy Education, 2019), curricular integration in pharmaceutical education has been the focus of many Faculties of pharmacy, and it is now recognized as an essential educational strategy for effective and comprehensive teaching (Pearson and Hubball, 2012).

Pharmacology is a cornerstone of various curricula of pharmacy, medicine, dentistry, nursing, physiotherapy, and veterinary medicine schools (Badyal, 2018). It provides a solid foundation of basic concepts (ie, mechanism of action, adverse effects, pharmacokinetic properties) crucial for the understanding of patient-specific drug-related problem and therapies (Jefferies et al., 2010). Nevertheless, the depth and width of the pharmacological content is defined by the outcomes-based framework delineated by the curriculum committee. Thus, for the pharmacy students to efficiently participate in coordinating drug therapy management, an in-depth knowledge and thorough understanding of basic pharmacology is needed (Engels, 2018).

Teaching and learning pharmacology are challenging, and with an increasing volume and fast pace of drug discovery, pharmacology education will become more challenging (Lerchenfeldt and Hall, 2018). On the other hand, the continuous updates in pharmacology are inevitable for ensuring safe, better and effective patient care. Nonetheless, considering the dynamic nature of pharmacology, there has been a substantial pressure to make pharmacology teaching efficient in a timely manner. It is well-known also that proper knowledge and interpretation of laboratory test results provide considerable opportunities for improving health outcomes. First, it helps in selecting drug of choice based on laboratory-based indications and contraindications. Second, it is critical to drug dosing adjustment and titration. Third, it allows monitoring of drug-related toxicities and effectiveness. Finally, it prevents misinterpreting results in instances where drugs interfere with laboratory measurement (Schiff et al., 2003). For these reasons, laboratory data and diagnostic approaches, pertinent to diseases tackled in the pharmacology and pharmacotherapeutic courses integrated in the pharmacy curriculum, are delivered to third level pharmacy students explicitly and sufficiently enough for their pharmacy careers. The course aims to provide students with a clear and useful introduction to the fundamentals for interpreting common laboratory test results. Most importantly, the course streamlines the transition from classroom to small-group practice setting for more effective development of the students’ skills in the analysis and interpretation of laboratory data.

The Faculty of Pharmacy at Beirut Arab University in Lebanon has extensively invested time and effort in constructing strategies to efficiently integrate courses, the successful accomplishment of which has been granted the international accreditation from the Canadian Council for Accreditation of Pharmacy Programs. Accordingly, and as part of the curricular revision initiated in the fall 2014 term, a 6-courses pharmacology series has been included in the 10-semester pharmacy program (Fundamentals of pharmacology and Pharmacology I-V). Each pharmacology course in the series is designed to span consecutively a full semester, starting semester 5. The pharmacology courses have been horizontally and vertically integrated with laboratory data, medicinal chemistry and pharmacotherapeutics courses. Moreover, they have been supplemented by integrated case-based learning sessions in alignment with the summer pharmacy experiential demonstration for fostering student higher-order learning.

This study aims at (1) presenting a multidisciplinary integrated approach, employed by the Faculty of Pharmacy at Beirut Arab University, to teaching third level pharmacy students about asthma and chronic obstructive pulmonary disease (COPD), and (2) assessing the student’s satisfaction and performance in the integrated approach.
2. METHODS

2.1. Subjects

Eligible students for inclusion were those who had successfully completed prerequisite courses in physiology (semester 2 and 3) and fundamentals of pharmacology (semester 5), through which they learned the basics of lung function and pharmacology principles, respectively (as shown as Fig. 1). Alongside, students must have passed the prerequisite biochemistry course (semester 4), pertinent to biochemical processes in order to enroll in laboratory data (semester 5). Totally, the study participants were 92 third-level bachelor of pharmacy students who were enrolled in the Fall semester of the 2017-2018 academic year.

2.2. Design

The material, taught in the fundamentals of pharmacology during semester 5, encompassed the pharmacology of autacoids and drugs affecting the autonomic nervous system. Thus, it served as a vital precursor to the bulk information delivered in the Pharmacology I course about asthma or COPD pharmacological management, which embraces antihistaminics, mast cell stabilizers, beta agonists and antimuscarinics. Definitely, student enrollment in the medicinal chemistry course (semester 5 and 6) aided in drug information reinforcement. Each of these courses was a 14-week course normally delivered and supported by either weekly 2-hour integrated case-based learning or practical sessions.

After successful completion of the aforementioned prerequisite courses, registration in pharmacology I course (semester 6), relevant to asthma and COPD as well as gastrointestinal and bone disorders, is permitted. The multidisciplinary integrated approach was utilized in preparing third level pharmacy students for the co-requirese pharmacotherapeutics course, which follows next in the horizontally integrated schedule (as shown as Fig. 1).

Starting with the laboratory data course, delivered in semester 5, students learned about pulmonary function tests, which provide objective and quantifiable measures of lung function. In this context, students were acquainted with the instructional techniques required to perform spirometry, peak expiratory flow rate, body plethysmography and airway reactivity tests. Then, students were learned about the purpose of each test and its usefulness in evaluating and monitoring treatment effectiveness and safety as well as respiratory disease severity. Emphasis was placed on bronchodilator (reversibility) test, which could help to differentially diagnose asthma and COPD by measuring reversibility of airflow limitation after the use of an inhaled short-acting β-agonist bronchodilator (Sim et al., 2017). For instance, the forced expiratory volume in 1 second (FEV1) value, obtained by spirometry, was assessed by the students to determine the severity of obstructive lung disease. Additionally, FEV1 was manipulated by the students in the interpretation of the reversibility test, such...
that an increase in the FEV1 of greater than or equal to 12%, or greater than or equal to 200 mL, after bronchodilator use is indicative of a reversible airway obstruction, such as in asthma and not COPD (Gallucci et al., 2019). Students were also learned about other spirometry-derived parameters, such as forced vital capacity (FVC) and FEV1/FVC ratio (also known as FEV1%), which help distinguish obstructive and restrictive lung diseases (Gallucci et al., 2019). Furthermore, students were engaged with the interpretation of these tests results by presenting short in-class exercises to check their grasp of the material delivered.

As for the pharmacology I course, a brief synopsis on the pathogenesis and pathophysiology of asthma and COPD was introduced to students at the beginning of the class. Brainstorming techniques were then manipulated prior to shifting to the pharmacology part with the aim of boosting their critical thinking and scintillating their creative prediction of potential pharmacological interventions. Subsequently, students were provided with a detailed knowledge of the commonly used drugs, pertinent to the cellular and molecular mechanisms of action, pharmacokinetic aspects and adverse effects. To facilitate memorizing of the latter, the instructor expanded on illustrating adverse event pathogenesis, which could arise from the interaction of drug with primary or off-target in primary or different tissue (Berger and Iyengar, 2010).

Laboratory data and pharmacology I contents were delivered to students through didactic classes using PowerPoint presentations. The information was usually presented in a simple bullet format, so that students could have time to copy information from the slides, while still being able to easily read and understand. Also, embedded within the presentations were colored figures for better elucidation of the drug-related mechanisms of action and adverse effects.

Inasmuch as active student learning strongly influences student-learning outcomes, new pedagogical approaches were applied in pharmacology I classes, through which the first author teaches about respiratory diseases. In alignment with the course objectives and the applied teaching style, these activities were designed to assist students in thinking critically, developing their collaborative skills and promoting their problem-solving skills in a more student-centered environment. The applied activities included information search, through which students search for information (normally covered in a lecture-based lesson) that answers questions posed to them (Silberman, 1996), and flipped classroom, a reversal of traditional teaching where small group students gain first exposure to new material outside of class, and then assimilate that knowledge during their classroom time through strategies such as PowerPoint presentations, discussion or debates (Singh et al., 2018).

Considering that the material is, although simplified, bulky and tough, and that most students find exams enormously stressful and that high level of test anxiety can compromise performance, the laboratory data course-related assessments were structured to be group exams. By definition, students were convened in groups to work together on test questions in order to considerably reduce anxiety and to engage them in collaboration with each other. Assessments in laboratory data were in the form of one-hour open-book group exams revolving about asthma- and COPD-related case studies, where students, sitting in groups, are allowed to bring notes and/or other resources into the exam room. Written summative assessments in pharmacology consisted mostly of multiple-choice questions and few short note questions, addressing the designed learning outcomes (LO) for each course at multiple levels of student learning. The LO of pharmacology I, laboratory data courses and pharmacotherapeutics I are listed in Table 1. Unquestionably, students were provided with the opportunity to revise and discuss exam results in order to improve material comprehension and enhance their academic achievements. Students were invited to fill a 10-item close-ended questionnaire, which uses a Likert scale, to assess the extent of students’ satisfaction and to uncover shortcomings in the integrated approach. The scale scored from 1 (strongly disagree) to 5 (strongly agree). The study was deemed exempt by the Beirut Arab University Institutional Review Board (2019H-0050-P-R-0330).
2.3. Statistical Analysis

The analysis of the data obtained through the questionnaire was based on a descriptive study of the data reported by the different items, in which the percentage of responses of the scale for each item was calculated. A one-sample t-test was run to compare the students’ mean responses with the midpoint of the test variables (test value = 3) (Fonesca et al., 2013). For a confidence interval of 95%, responses that were below, above or equal to 3 were considered indicative of a negative, positive and neutral positioning, respectively. A Spearman's Rho Correlation was conducted to determine the relationship between the students’ performance (represented by grade point average, GPA) in laboratory data,
pharmacology and pharmacotherapeutics. The values of Spearman’s Rho Correlation of +1 or -1 indicate the positive strong correlation or negative strong correlation, respectively, between two variables. The relationship would be statistically significant if the p-value is less than 5% level of significance. Statistical analysis of data was performed using Statistical Package for the Social Science (SPSS) software, version 25.

3. RESULTS
Out of 92 students, four did not complete the survey form. Thus, a total of 88 evaluations were collected with an overall response rate of 96%. The student cohort consisted of 33 males and 55 females with an average age of 20 years (range:19-29).

As shown in Fig. 2, there were 84%-100% of students who indicated strongly agree to agree to 9 items on the survey. Survey findings showed that all of the respondents agreed that the courses topics were interrelated in a cohesive and concerted fashion, while 86% indicated that there was minimal redundancy and overlapping information, and 98% indicated that the multidisciplinary integrated approach improved their understanding of the tackled topics. Ninety-eight percent of the students agreed that the use of different active learning activities aided in achieving the learning outcomes. With respect to the assessment methods, 96% of the students indicated that they were fair and adequate. Findings of the present study also indicate that 97% of the students were highly satisfied with the integration process and appreciated the benefit of the integrated approach in enhancing their learning experience in the pharmacotherapeutics course. Further, 98% of the students recommended the incorporation of the multidisciplinary integrated teaching to other topics. However, a potential concern about the time allotted to pharmacology was expressed by the cohort, with the majority believing that it was insufficient (as shown as Fig. 2).

![Bar chart showing students' assessment of the multidisciplinary integrated approach to teaching laboratory data and pharmacology of respiratory diseases (n=88).](image)

As indicated in Table 2, the one-sample t-test showed a high significance difference between item mean score and 3. Furthermore, positive lower and upper confidence interval differences confirm the item mean score is greater than 3. In contrast, negative lower and upper confidence interval differences confirm item 6 mean score was significantly lower than 3, indicating that “the lecture time allotted to pharmacology was sufficient” is negatively perceived by the cohort.

To further investigate the impact of the multidisciplinary integrated module on the students’ performance in the pharmacotherapeutics course, correlations between pharmacology, laboratory data and pharmacotherapeutics GPA of the cohort were measured. The results are summarized in Table 3. As can be seen, there was a moderate, positive and statistically significant correlation between
laboratory data and pharmacotherapeutics GPAs (rs(86)=.38, p<.05). Likewise, there was a strong, positive and statistically significant correlation between Pharmacology and pharmacotherapeutics GPAs (rs(86)=.64, p<.05).

Table 2. One-sample t-test results on the students’ perception of the multidisciplinary integrated module.

<table>
<thead>
<tr>
<th>Test Value = 3</th>
<th>t</th>
<th>df</th>
<th>p value</th>
<th>Mean Difference</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) The course objectives were clear and have been fully achieved.</td>
<td>58.42</td>
<td>87</td>
<td>.000</td>
<td>1.89</td>
<td>1.83</td>
<td>1.96</td>
</tr>
<tr>
<td>2) The use of different teaching methods aided in achieving the learning outcomes.</td>
<td>31.08</td>
<td>87</td>
<td>.000</td>
<td>1.69</td>
<td>1.58</td>
<td>1.80</td>
</tr>
<tr>
<td>3) There was concerted and effective integration of the topics in the given courses.</td>
<td>39.46</td>
<td>87</td>
<td>.000</td>
<td>1.77</td>
<td>1.68</td>
<td>1.86</td>
</tr>
<tr>
<td>4) The integrated courses helped me better understand the tackled topics.</td>
<td>33.82</td>
<td>87</td>
<td>.000</td>
<td>1.75</td>
<td>1.65</td>
<td>1.85</td>
</tr>
<tr>
<td>5) The integrated courses helped me effectively apply the integrated knowledge in the pharmacotherapeutics course.</td>
<td>32.87</td>
<td>87</td>
<td>.000</td>
<td>1.76</td>
<td>1.65</td>
<td>1.87</td>
</tr>
<tr>
<td>6) The lecture time allotted to pharmacology was sufficient.</td>
<td>-7.23</td>
<td>87</td>
<td>.000</td>
<td>-.77</td>
<td>-.99</td>
<td>-.56</td>
</tr>
<tr>
<td>7) The lecture time allotted to laboratory data was sufficient.</td>
<td>17.57</td>
<td>87</td>
<td>.000</td>
<td>1.41</td>
<td>1.25</td>
<td>1.57</td>
</tr>
<tr>
<td>8) The rewash minimal redundancy and over lapping information.</td>
<td>14.11</td>
<td>87</td>
<td>.000</td>
<td>1.39</td>
<td>1.20</td>
<td>1.59</td>
</tr>
<tr>
<td>9) Methods of assessment were fair and adequate.</td>
<td>25.46</td>
<td>87</td>
<td>.000</td>
<td>1.65</td>
<td>1.52</td>
<td>1.78</td>
</tr>
<tr>
<td>10) I recommend the application of integrated teaching to other topics.</td>
<td>26.95</td>
<td>87</td>
<td>.000</td>
<td>1.73</td>
<td>1.60</td>
<td>1.85</td>
</tr>
</tbody>
</table>

Questions scores were normally distributed, as assessed by Shapiro-Wilk’s test (p>.05). df: Degree of freedom.

Table 3. Spearman’s rho correlations between students’ performance in pharmacology and laboratory data and student’s performance in pharmacotherapeutics I.

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>Laboratory Data GPA</th>
<th>Pharmacology GPA</th>
<th>Pharmacotherapeutics GPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacotherapeutics I</td>
<td>Correlation Coefficient</td>
<td>.38**</td>
<td>.64**</td>
</tr>
<tr>
<td>GPA</td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>88</td>
<td>88</td>
<td>88</td>
</tr>
</tbody>
</table>
4. DISCUSSION
This study touches upon the nature and effectiveness of multidisciplinary curricular integration in teaching third level pharmacy students about asthma and COPD. A strategically and consistently designed multidisciplinary integrated teaching about asthma and COPD provided the students with an enjoyable and effective learning experiences, through which they fruitfully integrated the knowledge gained from basic sciences, such as pharmacology I and laboratory data, with applied science, such as pharmacotherapeutics.

The observed statistically significant correlations between students’ performance in the basic sciences and clinical course implies that the incorporation of the integrated module in the pharmacy curriculum has a great potential to contribute positively to students’ performance in pharmacotherapeutics I. The design of the laboratory data course assisted pharmacy students in understanding and engaging with the materials tackled in advanced pharmacotherapeutics courses integrated in the pharmacy curriculum. This was successfully achieved by building and developing the basic skills needed in the analysis and interpretation of laboratory test results to ultimately ensure safe and effective patient’s treatment regimen. Moreover, the inclusion of the pathophysiology introductory part in the pharmacology I course provided opportunities for students to comprehend the rationale for the introduction of clinically used drugs in the treatment regimens, to understand rather than memorize the drug information and to improve their problem-solving skills (Tse and Lo, 2008). The present findings are in alignment with the results of a previous study, which showed that undergraduate pharmacy students at the University of Michigan feel that integrating pharmacology with therapeutics courses is a beneficial change to the curriculum (Beleh et al., 2015). Nevertheless, findings of the present study identified the insufficient allotted time for pharmacology I as a shortcoming of the multidisciplinary integrated module, underscoring an urgent need of fine-tuning of the curriculum.

Remarkably, the use of active learning activities deepened the conceptual understanding of the topics and stimulated the students to think outside conventional boundaries, as reported by previous studies (Gleason et al., 2011; Inra et al., 2017). Apart from providing a great avenue for students to focus on the higher levels of Bloom’s taxonomy (Marshall and DeCapua, 2013), the flipped classroom activities aid in developing important professional competencies, such as communicating effectively with patients whenever providing education, working in collaboration with the pharmacy team and other health professionals, making best use of resources in providing knowledge and ensuring continuity of self-learning (Baytiyeh, 2017). Additionally, previously deployed flipped classroom models taught as a continuum in the Faculty of Pharmacy at Beirut Arab University have proven to promote student satisfaction and engagement, and to raise proficiency (Ghoneim & El-Lakany, 2017).

The open-book group assessment method utilized in the laboratory data course did not rely on learn-and-regurgitate learning. Instead, it taught students how to take information and apply it in a thoughtful, deep manner. For this, it tested the students’ understanding of the material and skills in interpreting, thinking critically, and presenting organized and well-written answers, ie higher levels of Bloom’s taxonomy.

Although asthma and COPD multidisciplinary integrated module enhanced students’ development of lifelong learning skills and created team teaching spirit among instructors, it was fenced with many barriers. Extensive time and effort were required for avoided repetitions, periodic revision and ongoing improvement. In this regard, instructors teaching the various disciplines had to constantly consult each other and to logically and temporally sequence the course topics in order to maintain content consistency and coherence and to minimize redundancy. Moreover, the instructors had to collaborate in a teamwork spirit to schedule their courses in consecutive hours in the same classroom. The coordination process took place through informal discussions or through formal curricular committee or departmental meetings. Continuous follow up to adapt changes and modifications for guaranteeing success to the designed integrated system also required the instructors to be present at the same time, an effort which was deemed challenging and at the expenses of faculty schedules.

The study had some limitations as the sample size is small with no control group, thus questioning the validity of the findings. Data collection from a comparative control group was challenging given the inaccessibility to the historical control students, and their exposure to instructors
other than those in the concurrent study. However, high significance-levels gleaned from this study indicate low probability of error. Furthermore, the study was conducted in two topics from the whole course, asthma and COPD. Despite this limitation, the current study inspires future research on using the same integrated approach in teaching multiple topics for precise generalization. Notwithstanding, the multidisciplinary integrated teaching about asthma and COPD held great promise for retaining information at a faster pace. This was quite evident in the positive feedback of third level pharmacy students, strongly proclaiming for the success of multidisciplinary integrated education.

CONCLUSIONS
Pharmacology and laboratory test data are integral components of all healthcare education. A solid comprehension of both disciplines provides an important basic science foundation for achieving competence in clinical areas, namely, pharmacotherapeutics. The multidisciplinary integrated system followed in the Pharmacy program at Beirut Arab University successfully mystified the mosaic of many individual courses and positively imparted a congruent educational experience, which indisputably fostered information retention. Notably, students’ satisfaction with the asthma and COPD pharmacology and laboratory data, as well as their performance in the pharmacotherapeutics course was mirrored in their high recommendation of applying the integrated teaching to other topics.

REFERENCES