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Cover Page Footnote

We would like to acknowledge the students of MWU-CPG Class of 2017 as well as all faculty who instructed these students in IS3 and IS6.

Performance on Interdisciplinary Topics in an Integrated Pharmacy Course

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ABSTRACT

Objectives: Many colleges and schools of Pharmacy combine interdisciplinary topics such as pathophysiology, pharmacology, medicinal chemistry and therapeutics into one integrated course. Our main aim for this study is to determine if students pass integrated courses and yet fail to pass interdisciplinary sections of those courses.

Methods: Two representative integrated sequence courses were evaluated without any study-imposed intervention. Individual student examination scores (~140 students) were evaluated for overall performance as well as for performance on the interdisciplinary topics of pathophysiology/pharmacology, medicinal chemistry, and therapeutics. The degree of difficulty of the examination questions, as well as the test item discrimination, were also measured.

Results: There were students that passed the course but failed one, or more, of the interdisciplinary topics. Combining data from both courses, medicinal chemistry was the most frequently failed discipline (29 students), followed closely by pharmacology (22 students), and distantly by therapeutics (1 student). The examination questions for medicinal chemistry were not more difficult nor more discriminatory than the questions for the other disciplines.

Conclusions: These data indicate that students pass integrated courses, but fail to pass interdisciplinary sections of those courses, especially the pharmaceutical sciences. It is not known if these results are consistent, nor what long-term adverse consequences may result. These results inform curricular and assessment aspects of the pharmacy academy as pertains to establishing the scientific foundation required by the CAPE 2013 Educational Outcomes.

Keywords: integrated course; pharmacy curriculum; interdisciplinary; student performance; pharmaceutical sciences

INTRODUCTION

The first domain of the Center for the Advancement of Pharmacy Education 2013 Educational Outcomes states, in part, that students are to integrate knowledge from the foundational sciences to solve therapeutic problems and advance patient centered care. This foundational knowledge should be integrated by students to explain how specific drugs work and to evaluate their potential value in individuals and populations. Additionally it states that this foundational knowledge should be integrated throughout the curriculum.¹

The importance of integrating clinical and basic sciences has been described in the pharmacy academy. Using an integrated curriculum students see the content from multiple perspectives and are asked to progressively apply knowledge at higher levels and in more complex scenarios, leading to an increased likelihood of retaining and recalling the pertinent information in real-life situations.² When topics are presented in an integrated fashion the student is better able to grasp the inter-relatedness of them, and this ability to synthesize the content is considered a beneficial learning outcome.³

Obstacles and challenges to curricular integration have been described.³⁻⁷ Many faculty consider themselves as specialists in their chosen discipline and think first (and sometimes only) about that content when preparing lectures. The pharmacy curriculum, being founded on the sciences, is not naturally integrated and the different disciplines tend to separate out by both faculty and students.⁵ If faculty aren't flexible with what they believe students need to know, this 'need to cover content' may be a hindrance in team-taught courses.³ Other challenges involve content overlap, content discrepancy, poor examination coordination, and intensive effort and time from faculty.^{6,7}

Many schools and colleges of pharmacy are incorporating integrated curricula, partly in an effort to comply with CAPE 2013. Husband and colleagues present an evidence-based integrated interdisciplinary model and describe the integrated approach utilized at their school.⁵ Medina et al developed an integrated assessment method utilizing test questions that were written by both clinical and basic sciences faculty into their existing courses.⁸ However while systemic integration of pharmacy curriculum is said to enhance student learning², evidence to support the value of an integrated curriculum is not strong.^{4,5}

Midwestern University College of Pharmacy – Glendale is a three year accredited program that utilizes a four quarter yearly schedule. The integration of knowledge of the basic and pharmaceutical sciences with clinical skills is presented

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throughout the curriculum. Basic science courses (human physiology, immunology, molecular biology and human genetics, and microbiology) are provided during the first professional year (PS1) as well as pharmaceutical sciences courses (pharmaceutical calculations, pharmaceuticals, and pharmacokinetics and biopharmaceutics). Harden describes a continuum between the extremes of discipline-based teaching and full integration using the metaphor of a ladder with 11 steps that progressively incorporate more integration into the curriculum.⁹ The basic science courses would best fit with step 3 (harmonization) of Harden's integration ladder. The basic science faculty consult with one another and the pharmacy faculty to integrate content and there is an effort to deliberately relate these topics to pharmacy. However, the courses are stand-alone courses.

Beginning in the winter quarter of the PS1 year and continuing through the spring quarter of the PS2 year, the curriculum provides a series of nine courses that integrate the teaching of medicinal chemistry (MC), pharmacology and pathophysiology (PP), and therapeutics (TX). These Integrated Sequence courses (IS1-9) are a primary means of providing instruction in these topic areas, as there are no stand-alone courses in medicinal chemistry, pharmacology, pathophysiology, and few in therapeutics. Their original purpose best aligns with Step 9 (multi-disciplinary) of the integration ladder as described by Harden.⁹ The courses are team-taught and based on disease states of related conditions, for example, endocrine, cardiovascular, psychiatric, etc. The objective is to integrate the disease state content while still preserving the identity of each discipline and demonstrating how each contributes to the understanding of the disease state. The student is tasked with devising and evaluating a treatment plan for persons with the particular disease that include an understanding of the relevant pharmaceutical sciences. The faculty approach the disease state from their area of expertise, knowing that it is one of several relevant perspectives to the topic. The learning objectives implicitly show the interrelatedness of the disciplines. These IS courses have been part of the curriculum since the inception of our college.

There is little in the pharmacy education literature about integrated courses and the advantages or challenges provided by them. Marshall and Nykamp reported overall scores on integrated examinations comprising PP, MC, and TX, but not the examination results of each specific discipline.¹⁰ Our current study furthers the academic literature by evaluating the interdisciplinary student performance in integrated pharmacy courses.

As coordinators of IS3 and IS6 the authors have access to examination data from these courses and calculate the final

course grades. As teachers we are aware that it may be possible for students to fail one of these interdisciplinary sections and yet pass the overall examination, and subsequently pass the entire course. The main question this study sought to address was: Do students pass IS courses and fail to pass interdisciplinary sections of those courses? If the study finds that this does occur, secondary questions concern the overall frequency, and if a particular discipline is more frequently failed than others.

METHODS

This study utilized a fixed design of real world research.¹¹ We were interested in evaluating the existing curricular environment and process. The study looked at two representative integrated sequence courses (IS3 and IS6) that were provided to the Class of 2017 without any study-imposed intervention. IS3 is given in the spring quarter of the PS1 year, and IS6 is given in the winter quarter of the PS2 year. Each course had a total of 4 multiple-choice examinations. An overall course score of 70% or higher (considered minimal competence for the course) is required to pass the course and to progress in the curriculum. Five test questions were submitted per hour of didactic teaching by the involved faculty. Questions representative of the three disciplines (MC, PP, TX) were on each examination, although the proportion varied. In general, each examination breakdown is about 50% pharmaceutical sciences (MC and PP), and 50% clinical sciences (TX).

Students hand-marked (bubbled) their responses that were later scanned and converted into an electronic form utilizing Scantron® software (Scantron Corporation, Eagan, MN). Microsoft Excel (Microsoft, Redmond, WA) was employed to analyze examination data of individual student performance by interdisciplinary topic and by total class performance. Final grades were based on performance on all four examinations.

Data provided for each interdisciplinary topic were the number of questions, the level of difficulty of the questions, and number of students who failed that interdisciplinary topic. The degree of difficulty of the questions was determined by the percentage of students with the correct response, as well as by the performance of the Top 27% and the Bottom 27%. An indication of test question discrimination was obtained using the point biserial value. The point biserial for each test question provides an indication of item discrimination, ie, does the question distinguish high achieving from low achieving students. An overall discipline score of 70% or higher is considered minimal competence for each interdisciplinary section.

Examination data from approximately 140 students (approximately 93% of the matriculated class) were analyzed for each course. Data were excluded for all 'make-up' versions as these examinations were different from the original.

This study was approved by the Midwestern University Institutional Review Board as fulfilling the criteria for exempt review.

RESULTS

Overall Test Questions and Performance

The total number of test questions for each interdisciplinary topic is shown in Table 1. The TX section had the most test questions in each course. The PP and MC sections had the same number of questions for IS6. The MC section had the fewest test questions overall.

The performance of the class on all exams is shown in Figure 1. The average performance on all test questions was 83.2% (SD 14.5) in IS3 and 84.8% (SD 13.6) in IS6. For IS3, average performance was 81.7% (SD 14.0) for PP, 80.5% (SD 16.6) for MC and 85.6% (SD 13.5) for TX. For IS6, average performance was 83.3% (SD 12.3) for PP, 81.6% (SD 16.9) for MC and 87.5% (SD 11.4) for TX.

The performance of The Top 27% of the class was consistent for all test questions and by interdisciplinary topic, for both courses (~93%). The performance of the Bottom 27% of the class was more variable, ranging from ~69% to ~78%; these students tended to perform better on the TX questions.

The point biserial for all test questions, as well as for each interdisciplinary topic, is shown in Figure 2. We chose a point biserial value of $\geq .20$ to indicate a discriminating question, and a point biserial value of $\leq .15$ as non-discriminating. The majority of the questions were discriminatory, and approximately 20-30% were non-discriminatory (for all test questions and interdisciplinary topics).

Actual possible final course grades were A, A-, B+, B, B-, C+, C, and F. However, this degree of detail was not pertinent to our study so we combined same letter grades to give four possible course grades: A, B, C, and F (Figure 3). There were two course failures in IS3, and none in IS6.

Interdisciplinary Sections Performance

There were students who failed at least one interdisciplinary section in both courses. For IS3, 14 students failed the PP section (range 57-69%) and all passed the course except one; 19 students failed the MC section (range 58-69%) and all passed the course except one; 1 student failed the TX section (64%) and passed the course (Figure 4). For IS6, 8 students

failed the PP section (range 64-69%); 10 failed the MC (range 55-69%); and 0 failed the TX; all students passed the course (Figure 4). Combining both courses, the interdisciplinary topic most frequently failed was MC (29 students), followed by PP (22 students), and lastly TX (1 student).

The highest final grade obtained by a student who failed one section was a true 'B'; there were three of these students (1 in IS3 failed MC, 1 in IS6 failed PP, and 1 in IS6 failed MC). There were several students who passed the course (with a 'C') and who failed *two* sections (in IS3, 5 students failed both MC and PP and 1 student failed both MC and TX; in IS6 1 student failed both MC and PP).

DISCUSSION

These data suggest that students pass integrated courses, but do not have minimal competence in interdisciplinary areas that are important in pharmacy education, especially the pharmaceutical sciences.

The number of students who failed interdisciplinary topics seemed high to us, especially in IS3. We anticipated that there might be a few, but 19 students failing the MC topic is more than 10% of the class. Of these 19 students, 18 progressed to IS6 where three also failed MC (17%), indicating continued poor performance of this discipline by the same students. Similar results were found for PP; of the 13 students who failed PP in IS3 and progressed to IS6, three also failed PP in IS6 (23%). Looking at consistent failures irrespective of discipline, of the 28 students who failed any discipline in IS3, nine (32%) also failed any discipline in IS6. Since the examination questions were not more difficult in the disciplines in addition to the fact that there were almost no failures in TX, it would seem that these students may have focused on passing the TX and were not as concerned with failing one of the pharmaceutical sciences.

We were also surprised that there were *any* students that could fail two disciplines and still pass the course, although there were substantially fewer of these students. In IS3 there were six students and in IS6 there was one student. Perhaps not so surprising, of the six students with multiple failures in IS3, four had at least one discipline failure in IS6 (67%), again indicating continued poor performance by the same students.

Medicinal chemistry was the most frequently failed topic area, followed closely by pathophysiology/pharmacology and then distantly by therapeutics. Students may focus more on the content provided by pharmacists rather than on content provided by medicinal chemists and pharmacologists due to a perceived greater importance or relevance of this content to their future as a pharmacist. It has been considered that

pharmacy students do not often completely appreciate the foundational role of the basic and pharmaceutical sciences to their education.¹² This idea is embraced anecdotally by many in the academy, and our results do not detract from this commonly held belief.

Even though students most frequently failed the MC and PP sections, these questions were not markedly more difficult than the TX questions. As such, it may suggest that students are actively choosing to not prepare for these sections, especially the MC section in IS3 where it represented only 18% of the course. This was substantiated via informal feedback from students who indicated that some of their peers actively decided not to prepare well for the medicinal chemistry section. This 'choosing' was also identified as a problem by Thomas et al. after implementing an interdisciplinary curriculum.¹³ They found that students could progress through the curriculum without demonstrating competence in a given area of expertise when the integrated coursework examinations are the only means of summative assessment.

There is little in the pharmacy education literature about performance in integrated courses. Marshall and Nykamp reported that integrated examinations which had questions comprising PP, MC, and TX had an average of 82% correct overall,¹⁰ a value that is similar to what we report here. However, these authors did not report the examination results of each specific discipline.

We note that this study provides observations of how students performed on interdisciplinary sections of integrated sequence examinations, and suggests, based solely on the results from those examinations, that students may not be competent in certain pharmaceutical sciences. While this outcome is certainly something that most would consider undesirable, it is not clear what, if any, long-term adverse consequences would result. Another measure of competency is performance on the NAPLEX, and while the students involved in this study have not yet taken the NAPLEX, the college's first time pass rate is consistently above the national average.¹⁴

It is not known whether these performance results consistently occur or if this particular class represents spurious results. We plan a three-year longitudinal study to help determine if this is a consistent outcome. We would encourage other schools and colleges of pharmacy that utilize these types of integrated courses and examinations to perform similar analyses and to share results with the academy. We are all tasked with fulfilling the CAPE 2013 Educational Outcome that students integrate the foundational sciences to advance patient care and to explain therapeutic problems.

If these results should prove to be consistent, then other questions become relevant. Do these students fail other courses, or APPE rotations, or some other indicator of academic success? Or do they continue throughout the program without incident, graduate and enter the professional field? If the former, standard academic procedures, such as remediation and tutoring, may be the remedies. If the later scenario, then one possible remedy might be to require a score of 70% on each discipline-specific section of the exam. Alternatively, students could be required to answer correctly a smaller, additional set of questions that test for key knowledge or threshold concepts as described by Husband et al.⁵ Examples of these key knowledge topics could include calculation of creatinine clearance, effect of autonomic nervous system on cardiac function, and role of functional groups to the properties of the pharmacophore. We finally note the importance of the commitment of the faculty who are involved in integrated courses to work closely together and have meaningful, substantive discussions regarding not only the content but also the assessments of the courses. Providing course assessments utilizing examinations questions that are more integrated may provide avenues for future improvements and ways to assist student pharmacists in solidifying the content of the pharmaceutical sciences.

SUMMARY

We evaluated student performance in two integrated, interdisciplinary courses utilizing the existing curricular process without any study-imposed intervention. Analysis demonstrated that students are able to pass the course while failing interdisciplinary topics that are important to pharmacy education. The most frequently failed discipline was medicinal chemistry, followed by pathophysiology/pharmacology, and distantly by therapeutics. It is not known if these results are consistent nor if there are any long-term adverse consequences from them. It is a commonly held belief that students focus more on content delivered by pharmacists, and our results support this by showing that students perform better on the therapeutics section than on the pharmaceutical sciences sections. They also serve to inform the many schools and colleges of pharmacy which utilize integrated-type courses of a potential challenge in how they are assessed.

Disclosures: None

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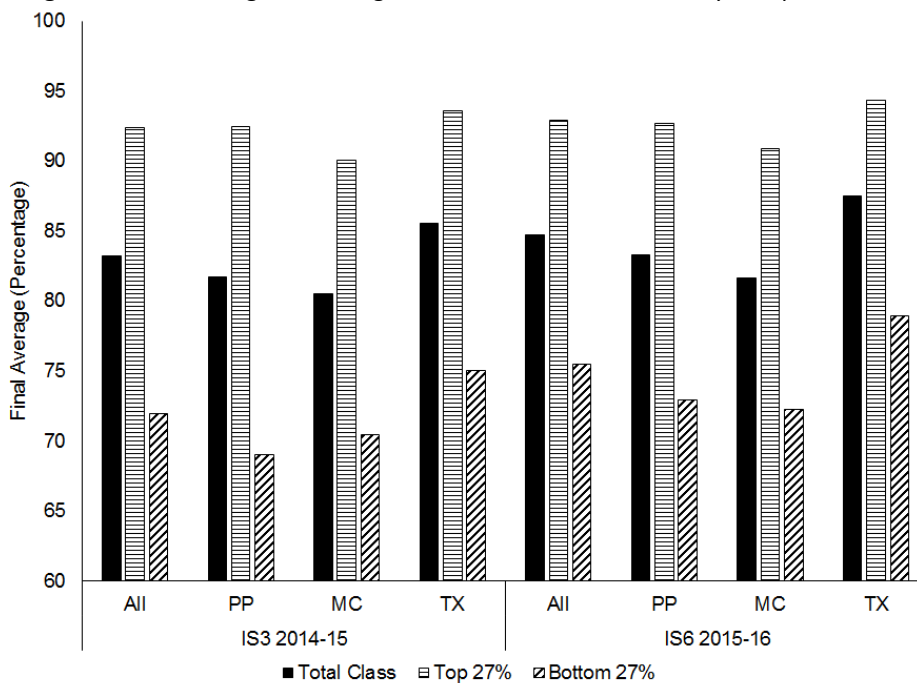
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Table 1. Number of Test Questions Per Topic for Each Course

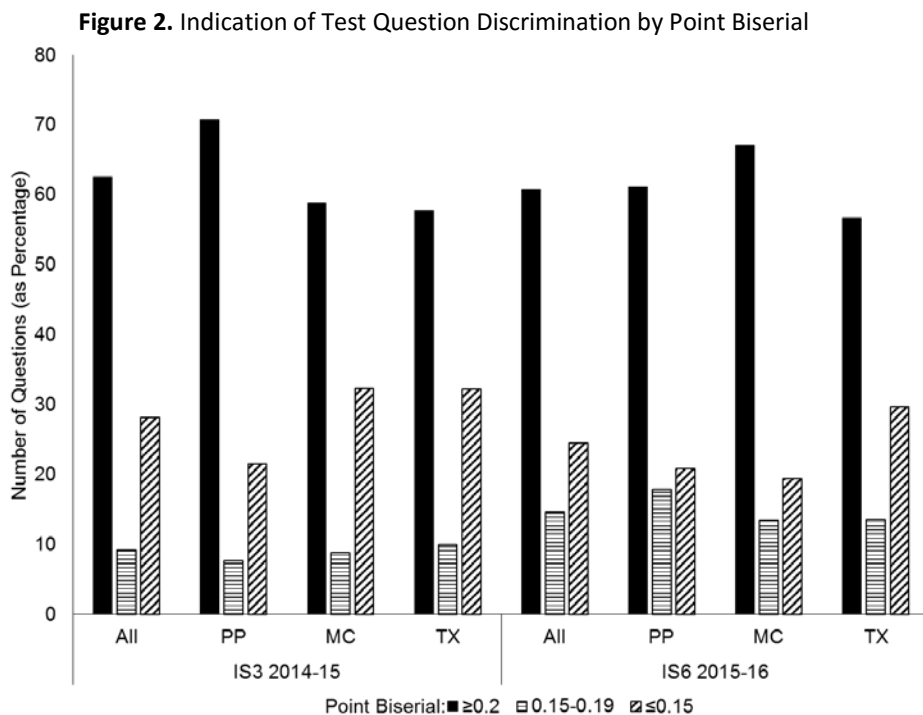
Course	Interdisciplinary Topic		
	Pathophysiology/ Pharmacology	Medicinal Chemistry	Therapeutics
IS3	65	34	90
IS6	67	67	111

Abbreviations: IS3 = Integrated Sequence 3; IS6 = Integrated Sequence 6

Figure 1. Final Average Percentages for All Test Questions and by Disciplines

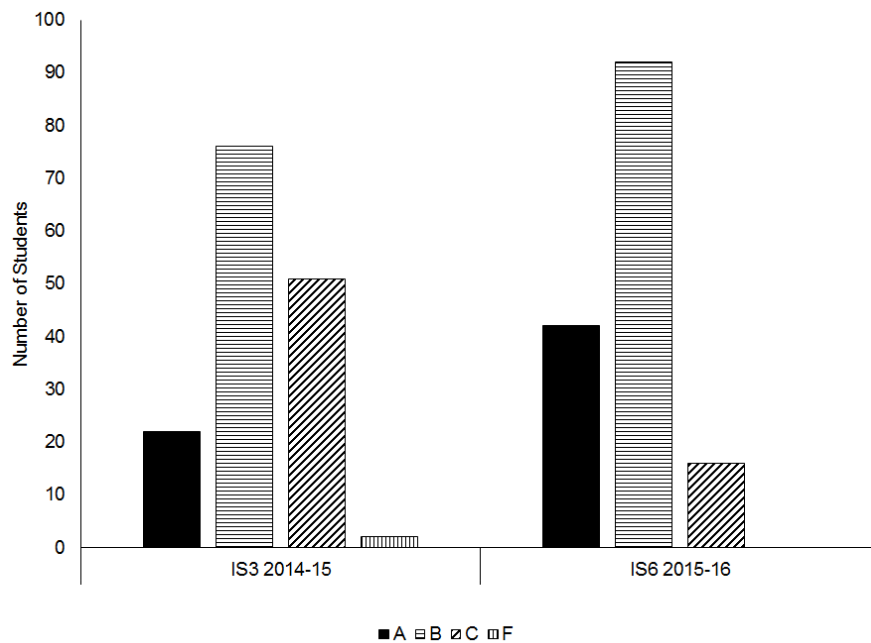


Abbreviations: IS3 = Integrated Sequence 3; IS6 = Integrated Sequence 6;
 PP = pathophysiology/pharmacology; MC = medicinal chemistry; TX = therapeutics



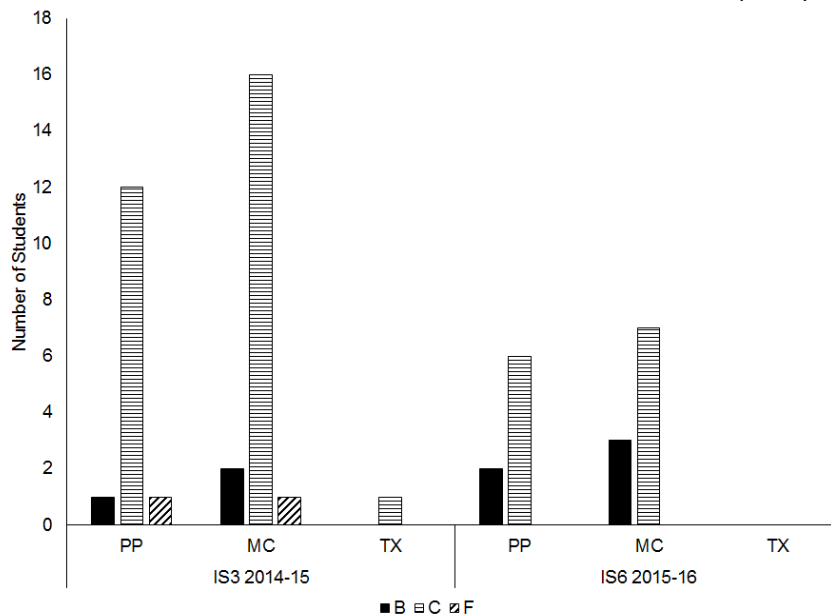
Abbreviations: IS3 = Integrated Sequence 3; IS6 = Integrated Sequence 6;
 PP = pathophysiology/pharmacology; MC = medicinal chemistry; TX = therapeutics

Figure 3. Final Grade Distribution for Each Course



Abbreviations: IS3 = Integrated Sequence 3; IS6 = Integrated Sequence

Figure 4. Final Course Grade for Students Who Failed at Least One Interdisciplinary Topic



Abbreviations: IS3 = Integrated Sequence 3; IS6 = Integrated Sequence 6; PP = pathophysiology/pharmacology; MC = medicinal chemistry; TX = therapeutics