

Linking Student Achievement in Didactic and Skills-Focused Pharmacy Practice Courses to Advanced Pharmacy Practice Experiences

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Abstract

To examine whether students' scores on pharmacy practice didactic examinations and skills-based, performance-oriented assessments are associated with their outcomes during advanced pharmacy practice experiences (APPEs). A retrospective study was conducted using records from graduates between 2018 and 2020. Students were classified as poor APPE performers (final APPE grade <83 percent) or acceptable performers. Examination results and performance-based assessment scores from pharmacy practice didactic and skills-focused courses completed in the second and third professional years were analyzed, applying predefined grade thresholds aligned with course cutoffs. Associations between low mean examination scores, performance-based assessments, and APPE performance were evaluated. Among 403 graduates, analyzable sample sizes varied from 254 to 403. Forty-nine students (12%) were identified as poor performers during the APPE year. In comparisons of didactic course outcomes with APPE performance, mean examination scores below 83% in six of seven pharmacy practice didactic courses were significantly associated with poor APPE performance, while five of seven courses showed significant associations at the <78 percent threshold. Several performance-based assessments demonstrating significant associations with APPE underperformance emphasized higher-order cognitive and critical thinking skills. The findings reveal a gap in early detection of students who ultimately perform poorly during APPEs despite passing didactic coursework. Emphasizing assessments that require critical thinking within the pre-APPE curriculum may improve early identification of at-risk students. Such approaches may be transferable to other pharmacy programs seeking curricular indicators to guide targeted academic support before the APPE year.

Keywords: Pharmacy practice, Advanced pharmacy practice experience, Skills-based assessment, Academic performance

Introduction

Pharmacy schools play a critical role in ensuring that students succeed in advanced pharmacy practice experiences (APPEs) by closely monitoring performance in the pre-APPE curriculum and providing remediation when necessary [1]. Remediation before or during APPEs can be resource-intensive, requiring considerable faculty effort and institutional support [2, 3]. Developing

a structured process to guide these remediation decisions could help programs efficiently allocate their limited resources. A key step in this approach is identifying elements of the pre-APPE curriculum that are predictive of performance during APPEs.

Previous research on pre-APPE predictors has primarily focused on student demographics and final course or examination outcomes, examining their links to APPE readiness or performance. For instance, Call *et al.* assessed factors including grade point average (GPA), course grades, performance-based and examination scores, professionalism issues during introductory pharmacy practice experiences (IPPEs), and academic honor code violations [4]. Similarly, Nyman *et al.* explored the predictive value of demographics alongside admission data and didactic performance metrics [5].

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Both studies indicated that cumulative pharmacy knowledge and age at program entry were more closely associated with APPE readiness than skills-based assessments or other demographic variables [4, 5].

In medical education, predictors of student success have been examined across demographics (e.g., gender), prior educational background (e.g., undergraduate major), aptitude/performance measures (e.g., standardized test scores), and noncognitive traits such as curiosity [6–10]. The use of pass-fail grading in many medical schools complicates the identification of preclerkship predictors. For example, Harvard Medical School found that students who frequently scored in the bottom quartile on first-year exams were more likely to perform poorly on later knowledge-based assessments and experiential clinical rotations [11].

Within pharmacy education, the link between performance-based assessments in skills-focused courses—central to the PharmD curriculum—and APPE readiness remains inconclusive. Moreover, some students underperform during APPEs despite not being flagged in the pre-APPE curriculum. This study aims to evaluate how pharmacy practice didactic examinations and performance-based assessments relate to student outcomes during APPEs.

Materials and Methods

The University of Wisconsin–Madison School of Pharmacy offers a four-year PharmD program, where the first three years consist of didactic courses, skills-based courses, and IPPEs. During the second (P2) and third (P3) years, students complete seven didactic pharmacy practice courses, including pharmacokinetics, four pharmacotherapy courses, nonprescription medications, and drug literature evaluation. Assessments include examinations and smaller assignments such as quizzes and problem sets.

Skills-based training is delivered through the Integrated Pharmacotherapy Skills courses (I–IV), which start in the second year and focus on developing practical skills and critical thinking through simulated patient and provider encounters, evaluated formatively and summatively [12]. Each course includes roughly eight one-hour discussions and eight three-hour lab sessions per semester. For this analysis, both didactic and skills-based pharmacy practice courses were included [13–15]. Unweighted mean exam scores were used to measure didactic course performance.

In the fourth year (APPE year), students participate in clinical rotations across Wisconsin under licensed pharmacist supervision. The APPE curriculum includes four required core rotations (acute care, ambulatory care, community pharmacy, and health-system pharmacy) and three to four elective rotations, each lasting six weeks.

This study utilized a retrospective approach, examining records from the University of Wisconsin–Madison PharmD graduating classes of 2018, 2019, and 2020. Data were sourced from both the university's learning management system and an established online clerkship database. The final APPE rotation for the 2020 cohort was excluded due to pandemic-related disruptions and associated stress. All students were retained in the analysis, regardless of any irregularities in academic progression. Several data points were missing, including one semester for a single course, primarily due to curricular changes and the transition between learning management systems; no imputation was performed for these missing values.

To classify student performance, final APPE scores were coded to distinguish “poor performers” from “acceptable performers.” To enhance early identification of at-risk students, mean exam thresholds of <83% and <78% were applied rather than relying solely on traditional failure definitions. Students scoring below 83% were categorized as poor performers, while those scoring $\geq 83\%$ were deemed acceptable. Performance in seven didactic courses and four skills-based courses was similarly coded. For didactic courses, the <83% and <78% thresholds corresponded to the minimum grade for a B (GPA 3.0) and BC (GPA 2.5), respectively. For performance-based assessments, lower thresholds of <78% and <70% were used, reflecting the campus grading cutoffs for BC and C (GPA 2.0). These reduced thresholds aimed to identify students struggling with higher-order skills and increase applicability to programs that utilize pass-fail grading for critical performance assessments. Students earning less than a C in any didactic course were also flagged as poor performers.

Descriptive analyses were conducted, and Fisher's exact tests were employed to evaluate associations between underperformance in didactic or skills-based courses and APPE outcomes, as both variables were binary. A subanalysis using Fisher's exact test assessed how the number of courses in which a student performed poorly related to APPE performance. Additionally, logistic regression was conducted as a sensitivity analysis including all didactic courses to explore predictors of

APPE underperformance. Data analysis was performed using StataSE 16 (StataCorp LLC). The study was deemed a quality assurance project by the University of Wisconsin–Madison Institutional Review Board.

Results and Discussion

From the three graduating cohorts, 403 students completed the PharmD program. Due to missing or incomplete data, sample sizes for specific analyses varied between 254 and 403 students. Forty-nine students (12%) were classified as poor APPE performers. Among these, 38 underperformed in a single APPE rotation, six in two rotations, four in three rotations, and one in five rotations. Six students failed at least one APPE during the fourth year. Across the three years, students received APPE grades below 83% in 18 rotations (2018), 20 rotations (2019), and 29 rotations (2020). Despite these challenges, all students ultimately graduated.

When didactic mean exam scores were compared with APPE performance, nine students in the poor APPE group (18.4%) and 21 in the acceptable group (6%) earned less than a C in any didactic course ($p = .006$). Using the <83% and <78% thresholds, the number of pharmacy practice didactic courses in which students underperformed was significantly associated with APPE poor performance (**Figure 1**).

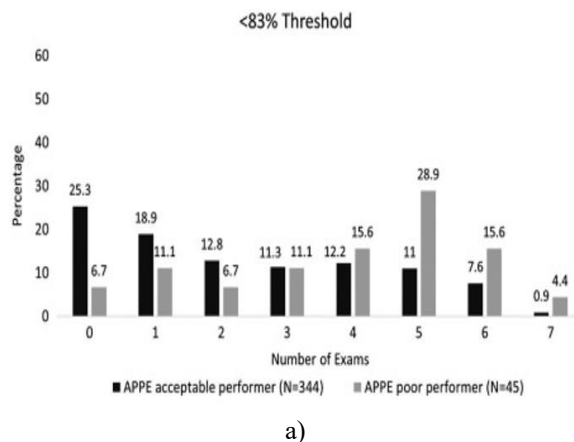


Table 1. Association between didactic examination performance and APPE poor performers at <83% threshold

Course/Item	Proportion of didactic PP <83%, No. (%)	Frequency of didactic PP and APPE AP (n=351), No. (%)	Frequency of didactic PP and APPE PP (n=49), No. (%)	p-value	Frequency of didactic AP and APPE PP compared to overall didactic AP, No. (%)	Frequency of didactic PP and APPE PP compared to overall didactic PP, No. (%)	Total Students (N)

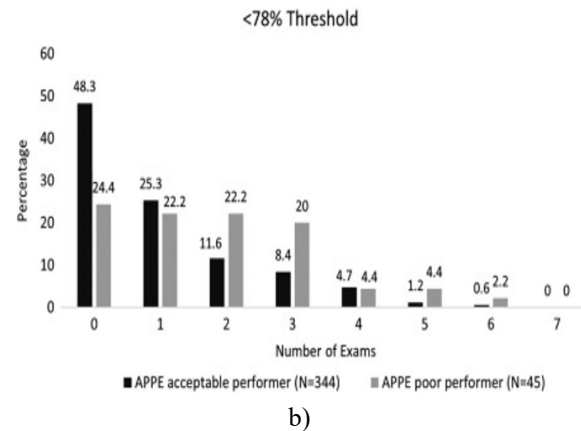


Figure 1. Distribution of courses with poor didactic exam performance by APPE outcomes. The x-axis (0–7) represents the number of courses in which a student’s mean examination score fell below the specified threshold, and the percentages above each bar indicate the proportion of students. Abbreviation: APPE = advanced pharmacy practice experience.

Analysis of the relationship between didactic mean examination scores and APPE outcomes revealed that students classified as APPE poor performers had a significantly higher proportion of low didactic exam scores compared with APPE acceptable performers (**Tables 1 and 2**). This pattern held true across both thresholds: six out of seven didactic pharmacy practice courses showed significance at the <83% cutoff, while five out of seven were significant at the <78% cutoff. Sensitivity analysis using logistic regression supported these findings, confirming that the same six courses maintained a positive association between low mean examination scores (<83%) and a higher likelihood of poor APPE performance.

PK Examinations	241 (61)	203 (58)	38 (78)	.001	11 (7)	38 (16)	396
Therapy I Examinations	195 (49)	164 (47)	31 (63)	.009	18 (9)	31 (16)	396
Therapy II Examinations	141 (36)	119 (34)	22 (45)	.064	27 (11)	22 (16)	397
Drug Literature Examination	132 (33)	105 (30)	27 (55)	<.001	22 (8)	27 (20)	398
Nonprescription Examinations	34 (9)	22 (6)	12 (24)	<.001	37 (10)	12 (35)	397
Therapy III Examinations	112 (28)	89 (25)	23 (47)	.001	26 (9)	23 (21)	394
Therapy IV Examinations	145 (36)	117 (33)	28 (57)	.001	21 (8)	28 (19)	403

Table 2. Association between didactic exam performance and APPE poor performers at <78% threshold

Course/Item	Didactic PP & APPE PP (n=49), (No., %)	Didactic PP <78% (No., %)	Didactic PP & APPE AP (n=351), (No., %)	p-value	Proportion of Didactic AP within APPE PP (No., %)	Proportion of Didactic PP within APPE PP (No., %)	Total Students (N)
PK Examinations	24 (49)	147 (37)	123 (35)	.025	25 (10)	24 (16)	396
Therapy I Examinations	17 (35)	93 (23)	76 (22)	.022	32 (11)	17 (18)	396
Therapy II Examinations	9 (18)	49 (12)	40 (11)	.11	40 (11)	9 (18)	397
Drug Literature Examination	10 (20)	54 (14)	44 (13)	.085	39 (11)	10 (19)	398
Nonprescription Examinations	2 (4)	3 (1)	1 (0.3)	.002	47 (12)	2 (67)	397
Therapy III Examinations	10 (20)	36 (9)	26 (7)	.003	39 (11)	10 (28)	394
Therapy IV Examinations	14 (29)	62 (15)	48 (14)	.006	35 (10)	14 (23)	403

Abbreviations: APPE = Advanced Pharmacy Practice Experience; PP = Poor Performer; AP = Acceptable Performer; PK = Pharmacokinetics; Therapy I–IV = Pharmacotherapy I–IV courses; APPE PP = students who scored <83% during an APPE

Across the skills-based courses, every semester's curriculum incorporated both performance-based assessments that had significant predictive value and those that did not (**Tables 3 and 4**). Assessments demonstrating significance typically demanded higher levels of clinical reasoning from students. Furthermore,

assessments were more likely to show significance when a skill was evaluated summatively for the first time; in later, similar assessments, student performance during the APPE year generally became uniform and less distinguishable.

Table 3. Relationship between skills performance-based assessments and APPE poor performers at <78% threshold (n=399)
<BC grade threshold (<78%)

Course/item	Frequency of skills PP and APPE AP (n=350), No. (%)	Frequency of skills PP and APPE PP, No. (%)	Proportion of skills PP <78%, No. (%)	p value	Frequency of skills AP and APPE PP relative to overall skills AP, No. (%)	Frequency of skills PP and APPE PP relative to overall skills PP, No. (%)

Fall P2 year (PP n=49)						
Skills I PBE consult, communication	1 (0.3)	1 (2)	2 (0.5)	.23	48 (12)	1 (50)
Skills I PBE consult, content	55 (16)	16 (33)	71 (18)	.005	33 (10)	16 (23)
Skills I PBE PPCP activity	73 (21)	18 (37)	91 (23)	.016	31 (10)	18 (20)
Spring P2 year (PP n=47)						
Skills II PBE consult, communication	4 (1)	0 (0)	4 (1)	1.0	47 (12)	0 (0)
Skills II PBE consult, content	29 (8)	8 (17)	37 (9)	.061	39 (11)	8 (22)
Skills II PBE SOAP note	87 (25)	16 (34)	103 (26)	.21	31 (11)	16 (16)
Skills II BP/HR	30 (9)	5 (10)	35 (9)	.59	42 (12)	5 (14)
Fall P3 year (PP n=37) ^a						
Skills III PBE patient case presentation to preceptor, content	72 (21)	16 (43)	88 (22)	.13	21 (7)	16 (18)
Skills III PBE patient case presentation to preceptor, communication	21 (6)	9 (24)	30 (8)	.009	28 (8)	9 (30)
Skills III PBE verbal provider communication (SBAR)	28 (8)	11 (30)	39 (10)	.009	26 (7)	11 (28)
Skills III women's health consult, content	63 (18)	15 (41)	78 (20)	.081	22 (7)	15 (19)
Skills III women's health consult, communication	60 (17)	9 (24)	69 (17)	1.0	28 (9)	9 (13)
Spring P3 year (PP n=37)						
Skills IV PBE patient interview	10 (3)	2 (5)	12 (3)	.65	35 (9)	2 (17)
Skills IV PBE SOAP note	4 (1)	0 (0)	4 (1)	1.0	37 (9)	0 (0)
Skills IV PBE patient case presentation to preceptor, content	30 (9)	10 (27)	40 (10)	.017	27 (8)	10 (25)
Skills IV PBE patient case presentation to preceptor, communication	40 (11)	10 (27)	50 (13)	.095	27 (8)	10 (20)

^aNote: Missing data for the graduating class of 2018; n=254 and n=32 APPE poor performers.

Abbreviations: P2 = second year of pharmacy school; P3 = third year of pharmacy school; APPE = advanced pharmacy practice experience; PP = poor performer; AP = acceptable performer; PBE = performance-based examination; PPCP = Pharmacists' Patient Care Process;

SOAP = subjective objective assessment plan; BP = blood pressure; HR = heart rate; SBAR = subjective background assessment recommendation; APPE PP = students who scored <83% during an APPE.

Table 4. Relationship between skills performance-based assessments and APPE poor performers at <70% threshold (n=399)
<C grade threshold (<70%)

Course/item	Total Skills PP <70%, No. (%)	Skills PP & APPE AP, No. (%) (n=350)	Skills PP & APPE PP, No. (%)	p value	Skills AP in APPE PP relative to total Skills AP, No. (%)	Skills PP in APPE PP relative to total Skills PP, No. (%)
Fall P2 year (PP n=49)						
Skills I PBE consult, communication	0 (0)	0 (0)	0 (0)	1.0	49 (12)	0 (0)
Skills I PBE consult, content	14 (4)	9 (3)	5 (10)	.018	44 (11)	5 (36)
Skills I PBE PPCP activity	42 (11)	31 (9)	11 (22)	.009	38 (11)	11 (26)

Spring P2 year (PP n=47)						
Skills II PBE consult, communication	1 (0.3)	1 (0.3)	0 (0)	1.0	47 (12)	0 (0)
Skills II PBE consult, content	3 (0.8)	2 (0.6)	1 (2)	.31	46 (12)	1 (33)
Skills II PBE SOAP note	37 (9)	28 (8)	9 (19)	.027	38 (11)	9 (24)
Skills II BP/HR	22 (6)	17 (5)	5 (11)	.16	42 (11)	5 (23)
Fall P3 year (PP n=37) ^a						
Skills III PBE patient case presentation to preceptor, content	57 (14)	47 (13)	10 (27)	.38	27 (8)	10 (18)
Skills III PBE patient case presentation to preceptor, communication	0 (0)	0 (0)	0 (0)	N/A	37 (9)	0 (0)
Skills III PBE verbal provider communication (SBAR)	21 (5)	15 (4)	6 (16)	.046	31 (8)	6 (29)
Skills III women's health consult, content	52 (13)	40 (11)	12 (32)	.039	25 (7)	12 (23)
Skills III women's health consult, communication	25 (6)	22 (6)	3 (8)	1.0	34 (9)	3 (12)
Spring P3 year (PP n=37)						
Skills IV PBE patient interview	3 (0.8)	3 (0.9)	0 (0)	1.0	37 (9)	0 (0)
Skills IV PBE SOAP note	1 (0.3)	1 (0.3)	0 (0)	1.0	37 (9)	0 (0)
Skills IV PBE patient case presentation to preceptor, content	12 (3)	9 (3)	3 (8)	.18	34 (9)	3 (25)
Skills IV PBE patient case presentation to preceptor, communication	32 (8)	26 (7)	6 (16)	.26	31 (8)	6 (19)

^aMissing graduating class of 2018; n=254 and n=32 APPE poor performers.

Abbreviations: P2 = second year of pharmacy school; P3 = third year of pharmacy school; APPE = advanced pharmacy practice experience; PP = poor performer; AP = acceptable performer; PBE = performance-based examination; PPCP = Pharmacists' Patient Care Process; SOAP = subjective objective assessment plan; BP = blood pressure; HR = heart rate; SBAR = subjective background assessment recommendation; APPE PP = students who scored <83% during an APPE.

This study indicates that evaluating multiple performance indicators within both didactic and skills-based courses can help identify students at risk for poor performance in Advanced Pharmacy Practice Experiences (APPEs). Specifically, the analysis suggests opportunities exist to detect at-risk students even if they have not failed a course, highlighting a gap in current identification practices. To better capture students at risk, we examined higher mean examination-score thresholds of <78% and <83%, finding that students repeatedly scoring between 70% and 83% were at increased risk for APPE poor performance. Furthermore, low performance in didactic courses was associated with poor APPE outcomes, reinforcing previously established relationships [4, 5]. Utilizing higher thresholds enables earlier identification of at-risk students through early warning and intervention systems, allowing pharmacy programs to provide

coordinated support to address gaps in knowledge and skills.

Skills-based assessments correlated with APPE performance primarily when they required content application and critical thinking, such as identifying and resolving drug-related problems or clinical documentation, whereas skills like communication or basic physical assessments (e.g., blood pressure measurement) were less predictive. This underscores the importance of direct observation and critical thinking-focused skills in the curriculum. Notably, these findings contrast with Call *et al.*, who advised against using performance-based assessments for progression decisions, as they found no link between skills practicum failure and APPE performance [4].

Compared to prior studies, this evaluation assessed pharmacy practice courses at a more detailed level, particularly within skills-based courses, and identified that some activities significant for APPE performance in early courses lost significance in later courses [4]. This suggests that students who struggle with critical thinking and skill application in pre-APPE courses may continue to face challenges during APPEs, where they encounter new environments, disease states, and increased patient complexity. Differences between our findings and those of Call *et al.* may also relate to grading methodology;

while they used pass/fail schemes, our point-based approach enabled evaluation at specific higher thresholds (<78% and <70%) [4]. Applying point-based grading, higher thresholds, and multiple skills assessments per semester provides an opportunity to identify at-risk students beyond a single summative assessment.

In line with accreditation requirements, our institution's early warning and intervention policy allows faculty to identify academic deficiencies at the course level to promote successful course completion [1]. The results suggest that these policies could be enhanced by longitudinally tracking students' performance across both formative and summative evaluations throughout the curriculum. Other pharmacy programs could adopt similar analyses to determine which assessments predict APPE performance and integrate them into early warning systems, establishing meaningful thresholds appropriate for their courses.

Sharing these findings with stakeholders may improve early identification of students who would benefit from intervention. For instance, instructors could prioritize remediation for students struggling with assessments predictive of APPE difficulties, while advisors and coordinators could use the data to promote self-reflection, metacognition, and performance improvement. Curriculum and assessment committees could undertake mapping exercises and faculty surveys to ensure that assessments predictive of APPE performance remain integrated over time.

Several factors potentially affecting student performance could not be systematically analyzed, including preferred learning styles, practice experiences, physical or mental health challenges, mindset, resilience, grit, and professionalism. The causes of poor performance are often multifactorial and complex, suggesting the value of a holistic approach to monitoring students and identifying academic and nonacademic contributors to poor outcomes [16, 17]. This evaluation also noted that students performing consistently in the BC/C range may still succeed in APPEs, possibly due to unmeasured variables or the inherent complexity of predicting performance. Performance in pharmaceutical sciences and social/administrative sciences courses was not assessed, limiting the holistic perspective of student achievement across the entire curriculum.

Future directions include refining early warning and intervention policies by adjusting monitored items, tracking the incidence of APPE poor performers to evaluate intervention effectiveness, and reviewing

assessment tools, rubrics, and weighting. Additionally, assessing students' self-efficacy in pharmacy practice skills could help triangulate the relationship between didactic performance and APPE outcomes.

Conclusion

This evaluation revealed a gap in identifying students at risk for APPE poor performance who had not failed didactic or performance-based courses. The findings could support student self-reflection and motivation, potentially improving APPE outcomes. Moreover, this approach could guide other pharmacy schools in recognizing critical curriculum components to identify and support students requiring remediation before entering APPEs.

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