RESEARCH

Evidence of Criterion Validity for One Pharmacy School's Progress Examination Program

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Objective. To provide evidence that the progress examination program accurately assesses student failure to demonstrate competence.

Methods. A progress examination program aligned with each grade level was locally developed and administered annually to 289 PharmD students in the spring of their first year – fourth year. Correlations and linear regressions were performed to compare the examination scores to performance on national licensing examinations and cumulative didactic grade point average (GPA). Odds ratio analysis was run to determine the ability of the passing scores of the progress examination to identify students at increased risk of failing to graduate on time, earn a GPA below 3.0, and fail the licensing examinations on their first attempt.

Results. Progress examination scores were strongly correlated to GPA and national licensing examination scores and weakly correlated to jurisprudence examination scores. Regression analysis indicated a significant linear relationship between examination scores and both GPA and the licensing examinations. Students who performed poorly on the progress examinations were more likely fail the national licensing examination, more likely to fail to graduate on time, and more likely to earn a cumulative didactic GPA below 3.0.

Conclusions. The second-year examination program strongly predicts students at risk for failure to graduate on time or achieve a GPA below 3.0, while all four examinations identify students at risk of failing the national licensing examination on their first attempt.

Keywords: assessment, educational outcomes, progress examination, milemarker examination, student progression, PCOA

INTRODUCTION

Many schools use some form of progress examination to assess student performance. Vyas et al identified 52 pharmacy schools in the United States with some form of a cumulative progress examination.¹ One major goal of these programs is to comply with accreditation standards, such as Standard 24 of the Accreditation Council for Pharmacy Education (ACPE) Standards 2016, which seeks to determine whether students are ready to pursue their final year of advanced practice experiences.² Ultimately, justifying valid conclusions and decisions for the progress of individual doctor of pharmacy (PharmD) students requires evidence of validity for use of an assessment such as a progress examination. In the past, validity was defined as three separate types: content, criterion, and construct, with concurrent and predictive validity based on the timing of data collection.³

Downing described validity as a unitary concept with construct validity as the whole of validity.³ In this view, validity is approached as a hypothesis. Assessments such as progress examinations are neither valid nor invalid. Assessment scores simply have more or less validity evidence to support their use for the proposed interpretation. Downing described five sources of validity evidence: (1) content; (2) response process; (3) internal structure; (4) relationship to other variables; and (5) consequences. While Downing's article reviewed validity as described in the 1999 Standards for Educational and Psychological Testing (SEPT), the SEPT 2014 retains this position when it states that "validity refers to the degree to which evidence and theory support the interpretations of test scores for proposed uses of tests."⁴

The Annual Skills Mastery Assessment (ASMA) examination program was developed by faculty members at Wingate University School of Pharmacy (WUSOP) as a criterion-referenced annual progress examination. The ASMA examination compares students to a faculty panel's

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estimate of competency on the grade-level appropriate skills [first year (P1) – fourth year (P4)] assessed on the examination. Evidence of validity should include how well the examination includes important content, aligns content with the curriculum, reflects what should be learned, reflects individual student scores in a meaningful way, allows cost-effective production, and delivers results in a timely fashion while measuring what it purports to measure.⁵ Previous articles explored the content, response process, and internal structure validity of the ASMA examinations, as well as the cut score development process.^{6,7} This study was designed to complete the initial validation process by analyzing the relationship to other variables and determining whether the cut scores identify students with increased likelihood of failure and thus can be predictive of competence (consequences).

METHODS

The development of the examination was described in detail in 2010.⁶ Briefly, faculty members developed a list of Terminal Ability- Based Outcomes statements (TABO) in 2003. These statements were categorized as abilities that should be developed during the first, second, third, or fourth year of the curriculum. Test items were written by faculty members and designed to assess practice skills rather than factual knowledge because knowledge-based examinations can potentially encourage memorization over higher levels of learning.⁴

Faculty panels then used an Angoff scoring process to determine the minimal level of performance (cut score) on each test item. The Angoff process produces a reliable cut score for this examination.⁷ The cut scores for all test items are averaged to create a cut score for each subscale and for the entire examination. Each student receives a customized individual score report that summarizes progress in mastering the TABO-specific subscores as well as the aggregate ASMA examination score. The score reports are distributed via the student's faculty advisor to facilitate a frank end-of-grade formative progress discussion with each student (Appendix 1).

Student performance data is aggregated to produce TABO-specific summative evidence of curricular learning outcomes for the curriculum committee called the Mastery Summary Report (Appendix 2). The multiple-choice, 4-option, single best answer examination has been used since 2008 to track the ability of the WUSOP curriculum to develop targeted program outcomes in students as they progress through the curriculum. In addition, student aggregate data can be studied to examine intercampus performance as well as current success vs historical trends. The outcomes assessment committee selects the TABO to be tested each year and develops

the test blueprint (Appendix 3). The students are not advised about examination content so they cannot skew the results by selectively studying for the examinations. All classes and practice experiences are cancelled and all tests are administered to all takers on a single day in late March each year. This assessment is designed to measure retention rather than short-term recall.

Reliability is the ability of an instrument to measure consistently.⁸ Internal consistency reliability is the test's correlation with itself.⁸ The ASMA examination metrics include Cronbach alpha, a measure of internal reliability, and the standard error of measurement (SEM), which is an estimation of measurement error.^{8,9} Cronbach Alpha over a 4-year period for P1 through P4 examinations ranged from a low of 0.69 to 0.88. The SEM describes the effect of measurement error on the observed score of an individual student.⁹ It estimates how repeated measures of a student on the same test tend to be distributed around his or her "true" score. The SEM ranged from 3.7 to 4.8, which equates to a measurement error between 2.4-3.7 points per 100 point examination. Roughly 68% of student scores would fall within 1 SEM on repeated retests and 95% within 2 SEM.

The project described herein was approved by the Wingate University research review board. Chisholm-Burns et al suggested that grade point average (GPA), North American Pharmacist Licensure Exam (NAPLEX) scores, and Multistate Pharmacy Jurisprudence Exam (MPJE) scores could be used as proxies for student success.¹⁰ These authors selected failure to achieve a GPA above 3.0 at the end of the didactic portion of the curriculum, failure to pass the NAPLEX on the first attempt, failure to pass MPJE on the first attempt, and failure to graduate on time (GOT) with their entering student cohort as proxies for failure to demonstrate competency in the abilities necessary to enter practice. Semester 6 GPA at the end of the didactic curriculum was used based on concerns that practice experience grades tend to be inflated, with at least one school reporting that 90% of them were As.¹¹

For the analysis in this study, student performance data for the graduating classes of 2011 to 2014 (N=290) were collected. Students who withdrew from the program prior to receiving any official grades for the first semester were excluded (n=1). Data collected included the percentage correct ASMA examination score for the P1, P2, P3 and P4 examinations, the cumulative GPA at the end of the didactic curriculum (GPA6), and whether or not the student graduated from the program on time with their entering cohort. Data collected that was external to the WUSOP program included the examination score for the NAPLEX and MPJE examinations. Some students may

take an ASMA examination more than once before they proceed to the next didactic year because they have academically repeated a year. The ASMA examination score reported in these data was for the first attempt of the test for that didactic year only.

Additional analysis fields were computed from the original data points. Each ASMA examination score was analyzed to determine if the student score: (1) fell below the mastery cut score for the examination; (2) fell within 1 SEM of the cut score; or (3) fell within 2 SEM of the cut score. New study variables were created to account for each of these three cases. This analysis was added to explore the chance that measurement error internal to the ASMA examinations may fail to identify a low performer if WUSOP relied solely on the cut score rather than including students who barely exceeded the cut score. In addition, each ASMA score was converted to a z-score using EzAnalyze Software (Boston, MA). The data was then dichotomized in to five groups based on z-score. The groups were: (1) below 2 standard deviations below the mean; (2) between -1 and -1.99 standard deviations below the mean; (3) between -0.99 and +1 standard deviations above the mean, 4) greater than 1 but less than 2 standard deviations above the mean; and (5) greater than two standard deviations above the mean. Finally, additional performance variables were created to denote whether students passed their NAPLEX and MPJE on the first attempt, achieved a GPA6 below 3.0 on a 4-point scale, and failed to graduate on time with their entering class. For students who took longer than six semesters to complete the program, the GPA data used was their cumulative GPA at the completion of all didactic instruction.

A correlation matrix was created for the primary performance variables. Guidance provided by the *British Medical Journal* was used to determine the strength of the Pearson correlation for this study. The journal contends that "If we wish to label the strength of the association, for absolute values of r , 0-0.19 is regarded as very weak, 0.2-0.39 as weak, 0.40-0.59 as moderate, 0.6-0.79 as strong and 0.8-1 as very strong correlation. . ."¹² The purpose of this analysis was to determine whether the ASMA scores were correlated to the proxies for failure to demonstrate competency. Correlations were run using the EZAnalyze add-in for Microsoft Excel.

Systat 13 (Systat Software Inc., San Jose, CA) was used to perform a linear regression analysis of each of the ASMA examinations (P1-P4) to NAPLEX, MPJE, and GPA6. The effect size estimate calculated used was R^2 . Cohen posited that R^2 of (0.10) equated to a small effect, (0.30) equated to a medium effect, and (0.60) equated to a large effect.¹³ A linear regression was used to quantify the relationship between the two sets of continuous variables.

A single-factor ANOVA analysis was performed comparing the ASMA examination z-score groups (1-5) to performance on the MPJE, NAPLEX, and GPA6. The Eta-Squared was calculated to estimate effect size. Eta-Squared is similar to the R^2 calculation and both describe the percentage of the observed effect that can be attributed to membership in the group being analyzed.¹⁴ This analysis determined whether poor performers (defined as outliers 2 SD below average) on the ASMA examinations were more likely to fail in the future. While this dichotomized data set is not appropriate as an unbiased estimate of the relationship between the continuous variables, such as ASMA score to GPA, it can be used in concert with the regression analysis to further describe the relationship were the regression results both statistically significant, as evidenced by the p value, and practically significant, as evidenced by the effect size.¹⁴

Finally, SYSTAT13 was used to perform a cross tabulation analysis and compute odds ratios. This analysis determined the 2-way comparison between student performance on the ASMA examination and performance on the selected proxies for failure. The cut score performance variables for each ASMA examination were compared to NAPLEX Failure, MPJE Failure, GPA6 under 3.0, and Failure to Graduate on time. This analysis was done to determine whether students who fail to master the ASMA examination were more likely to fail to demonstrate competence on the proxies for failure. This element becomes the most important evidence of consequential validity.

RESULTS

The ASMA examinations all correlated positively to GPA6 and NAPLEX score, with a much weaker association to the MPJE. The P4 ASMA examination scores strongly correlated to NAPLEX and GPA6 and weakly correlated to MPJE. The P3, P2, and P1 examinations moderately correlated to NAPLEX and GPA6, but weakly correlated to MPJE. All correlations were significant with p values < 0.01 (Table 1).

The regression analyses show that all four ASMA examinations (P1-P4) are significant predictors of NAPLEX, GPA, and MPJE (Figures 1, 2, and 3). The effect size estimates for NAPLEX and GPA in general indicated that the practical significance of the regression was larger for these two variables than for MPJE. The ASMA 1 examination showed a small effect size for NAPLEX and GPA while ASMA 2-4 showed medium effect size.

A graphic representation of the ANOVA analysis of each ASMA examination's z-score groups to NAPLEX and GPA6 is shown in Figures 4 and 5. The average poor performing student (-2 SD below average) on the ASMA

Table 1. Correlation of ASMA Exam Scores to NAPLEX, MPJE and GPA

	P1 ASMA	P2 ASMA	P3 ASMA	P4 ASMA	NAPLEX Scaled Score	MPJE Scaled Score
P2 ASMA	.64	1				
N	285					
P	.01					
P3 ASMA	.61	.78	1			
N	279	279				
P	.01	.01				
P4 ASMA	.59	.68	.77	1		
N	260	260	259			
P	.01	.01	.01			
NAPLEX-SS	.46	.56	.60	.70	1	
N	263	263	262	250		
P	.01	.01	.01	.01		
MPJE SS	.13	.21	.27	.30	.45	1
N	249	249	248	237	248	
P	.05	.01	.01	.01	.01	
Cumulative GPA	.53	.59	.57	.64	.59	.30
N	284	283	279	260	263	249
P	.01	.01	.01	.01	.01	.01

ASMA=Wingate Annual Skills Mastery Assessment Exam

NAPLEX-SS=North American Pharmacy Licensure Exam Scaled Score

MPJE=Multistate Jurisprudence Exam Scaled Score

Boldface Pearson Correlation Numbers denote strong correlations above 0.6

examinations failed to achieve a GPA6 above 3.0 and scored poorly on the NAPLEX. Results for the MPJE were not significant. The odds ratio analysis showed mixed results. The ASMA examination cut scores show no significant ability to predict MPJE failure, graduation on time, or cumulative didactic GPA below 3.0 with the exception of the P2 examination. Scoring below or within 1 SEM of the cut score on the P2 examination identified students at significantly higher risk for failing to graduate on time (OR 90) or earning a GPA6 below 3.0 (OR 9.69). Failing to master any of the ASMA examinations identified students at significantly higher risk of failure on the NAPLEX examination on their first attempt (Table 2).

DISCUSSION

While the regression analysis shows strong evidence of a convergent significant relationship between the ASMA examination scores and the NAPLEX, MPJE, and GPA6, the practical significance of these relationships is confirmed by the evidence of consequential validity provided by the odds ratio analysis. Students who score at or near the cut score on the ASMA examinations were much more likely to fail in the future. Each of the ASMA examinations demonstrated a significant ability to predict ability to pass the NAPLEX examination on the student's first attempt. The P2 examination in particular appears to show promise as a critical predictor of failure.

It is noteworthy that this examination seems to discern to a greater degree than either the P3 or P4 examination.

The correlation evidence and regression analysis provide even more evidence that the ASMA examinations appear to possess validity for their intended purpose. Similar studies in medical education compare progress-type examinations to measures of competency. Taylor et al analyzed the relationship between USMLE Step 1 and Step 2 examinations and GPA with the performance rating new physicians earned from their residency directors and found the following Pearson correlations: USMLE Step 1 (.30), USMLE Step 2 (.37), and GPA (.46).¹⁵ Wilkinson et al analyzed the relationship between the International Foundation of Medical Clinical Science exam developed by the National Board of Medical Examiners and the GPA of 426 Australian medical students and found a correlation of (0.55).¹⁶ McCaskill et al compared scores on the USMLE step examination to pediatric board certification examinations and found Pearson correlation of (0.67) for the step 1 and (0.62) for the step 2 examinations.¹⁷ In a pharmacy education example, Meszaros et al compared students' results on the PCOA examination to advanced practice experience grades and found a Pearson correlation of (0.34) with an R² effect size of (0.11).¹⁸ None of these studies are identically constructed and comparing R² between different studies is not appropriate. But the evidence of correlation of the ASMA examinations to NAPLEX and GPA combined with the

ASMA	No.	R ²	p Value
1	263	0.21	<0.001
2	263	0.32	<0.001
3	262	0.36	<0.001
4	250	0.48	<0.001

Dark lines represent the Upper and Lower Prediction intervals at 95% confidence

Grey Straight Lines represents the regression trend line

Grey Curved Lines represent the 95% confidence intervals

Dotted gray line equals passing score on the NAPLEX of 75

Figure 1. Linear Regression of Wingate Annual Skills Mastery Assessment Exam (ASMA) Scores to North American Pharmacy Licensure Exam Score with 95% Confidence Intervals.

ASMA	No.	R ²	p Value
1	284	0.28	<0.001
2	283	0.35	<0.001
3	279	0.32	<0.001
4	260	0.41	<0.001

Dark lines represent the Upper and Lower Prediction intervals at 95% confidence
 Grey Straight Lines represents the regression trend line
 Grey Curved Lines represent the 95% confidence intervals
 Dotted gray line equals GPA of 3.0

Figure 2. Linear Regression of Wingate Annual Skills Mastery Assessment Exam (ASMA) Scores to Cumulative Grade Point Average at Semester 6 with 95% Confidence Intervals.

ASMA	No.	R ²	p Value
1	249	0.016	0.045
2	249	0.045	0.001
3	248	0.073	0.001
4	237	0.092	0.001

Dark lines represent the Upper and Lower Prediction intervals at 95% confidence

Grey Straight Lines represents the regression trend line

Grey Curved Lines represent the 95% confidence intervals

Dotted gray line equals passing score on the MPJE exam of 75

Figure 3. Linear Regression of Wingate Annual Skills Mastery Assessment Exam (ASMA) Scores to Multistate Jurisprudence Exam (MPJE) Scores with 95% Confidence Intervals.

>2SD below = at least 2 Standard deviations below the mean, > 1SD and < 2SD = more than 1 Standard deviation below the mean but not more than 2, + or - 1SD = between 1 standard deviation above the mean and 1 below the mean, > 1SD but < 2SD = more than 1 standard deviation above the mean but not more than 2, > 2SD = more than 2 standard deviations above the mean

Figure 4. Wingate Annual Skills Mastery Assessment Exam (ASMA) z-scores to Grade Point Average 6 (GPA6).

medium effect size estimates suggests that the ASMA examinations are at least as useful as other widely studied examinations. For instance, all four ASMA examinations demonstrated both larger Pearson correlations and effect sizes when compared to NAPLEX and Cumulative GPA than the study of PCOA reported by Meszaros.¹⁸ Third-year ASMA correlates to GPA6 (0.57) with R^2 (0.32) while PCOA correlates to APPE grades (0.34), with an effect size of (0.11). The correlations to external grading measures were in a similar range with the studies of the USMLE. The P4 ASMA examination correlated to the

NAPLEX (0.70) at least as well as McCaskill's study of the USMLE to pediatric board examination scores (0.67).

The ANOVA analysis as a stand-alone measure of the relationship between the ASMA examinations and the chosen markers for failure would be questionable. MacCallum concluded that the process of dichotomizing continuous variables could lead to negative consequences, including the loss of information regarding individual differences, loss of power, and loss of effect size accuracy. This could lead to overemphasizing the effect size in cases where the grouping results in cohorts with

> -2 = at least 2 Standard deviations below the mean, > -1 = more than 1 Standard deviation below the mean but not more than 2, + or - 1 = between 1 standard deviation above the mean and 1 below the mean, > +1 = more than 1 standard deviation above the mean but not more than 2, > +2 = more than 2 standard deviations above the mean

Figure 5. Wingate Annual Skills Mastery Assessment Exam (ASMA) z-scores vs North American Pharmacy Licensure Exam (NAPLEX).

insufficient sample size.¹⁹ In this study, the relationship between the continuous variables was first confirmed with a linear regression of the entire data set with N ranging from 237 to 284, so the ANOVA should be considered in context with the regression findings. By breaking the continuous data for student performance on the ASMA examinations into z-scores, this ANOVA analysis helped to identify whether students who performed poorly on the ASMA examinations also performed poorly on the selected proxies for failure. Figures 4

and 5 identify a trend that students who performed poorly on the ASMA examinations also performed poorly on NAPLEX and GPA6. While the trend also existed for the MPJE, the low performing cohort did not fail on average, making the finding less significant.

The surprise from the ANOVA analysis was the ability of the P1 and P2 ASMA examinations to identify the group of performers who failed to pass the NAPLEX. The P1 examination identified a cohort of nine students who averaged 77.9 on the NAPLEX, eight of whom failed, and

Table 2. Odds Ratio Analysis of ASMA Exam Mastery vs NAPLEX Failure

ASMA Exam Score	Odds	CI
ASMA 4 Mastered		
ASMA4 +1 SEM ¹	96.8	2.7 – 6.5
ASMA4 +2 SEM ¹	80	2.8 – 6.0
ASMA3 Mastered	31.75	1.4 – 5.5
ASMA3 +1 SEM ¹	27	1.6 – 5.0
ASMA3 +2 SEM ¹	16.07	1.4 – 4.1
ASMA2 Mastered		
ASMA2 +1 SEM ¹	15.3	1.2 – 4.3
ASMA2 +2 SEM ¹	16	1.4 – 4.1
ASMA1 Mastered	17.8	1.3 – 4.5
ASMA1 +1 SEM ¹		
ASMA1 +2 SEM ¹		

ASMA=Annual Skills Mastery Assessment Exam

SEM¹=Standard Error of Measurement

“Mastered”=Above cut score

CI=Confidence Intervals

Nonsignificant findings left blank

the P2 examination identified a cohort of six students who averaged a 69 on the NAPLEX. They all failed their first attempt. This confirms the ASMA examinations are strong indicators of failure to demonstrate competency by passing the NAPLEX on the first attempt. However, the results are potentially biased by the small sample size of students who failed.

The school can predict which students are 18 times more likely to fail their NAPLEX by reviewing ASMA examination results at the end of their P1 year to determine students who failed to master the examination. This cohort of students varies from two to six individuals in any given year. These students must meet with their advisor and the administration to craft a remediation plan. Identifying these students is relatively easy. Crafting a customized and effective strategy that works for any one individual student has proven significantly more challenging and will require additional study.

Earlier articles established the validity of the process used to construct the ASMA examination to be certain that it was connected to competency-based outcomes and validated the reliability of the cut score development process.^{6,7} The data in this analysis provides compelling evidence that the ASMA examinations assess what they purport to assess, which is a reasonable estimate of the minimal level of competency of pharmacy students at WUSOP.

While the data presented here for WUSOP is not generalizable to any other school, the methodology is. No one assessment tool is capable of providing all of the assessment data a program needs to provide excellent education, and the ASMA examination is no exception. Standards 2016 make the administration of the PCOA

examination mandatory for students who have completed their didactic curriculum. In Appendix 3 of the ACPE Standards, the PCOA is solely designed to formatively assess Standard 1—the knowledge of the essential content listed in Appendix 1.²

Administering the PCOA does not, therefore, absolve a program of the responsibility to formatively and summatively assess Standards 2, 3, and 4. While no multiple-choice examination is likely capable of assessing all four standards, the ASMA examination thoroughly engages Standard 2 and the problem-solving elements of Standard 3. In addition, the ASMA examination provides WUSOP with accurate, actionable data to identify students likely to fail, while simultaneously providing the curriculum committee with validation for the achievement of learning outcomes in Standards 1, 2, and elements of 3. This ability to predict failure provides indirect evidence of student performance on Standards 3 and 4, as many of the students who fail to complete the program have exhibited nonacademic deficiencies in such areas as communications and professionalism.

All student competence studies are hampered by the inability to assess competence as a working professional. Therefore, pharmacy schools are left with NAPLEX scores as a proxy that may or may not truly assess competence. While the sample size of this study is reasonable (N=250), it still represents only four graduating classes. Because the number of failures is so small (less than 10% of the population), there is potential for significant measurement error. The ASMA examinations are subject to potential measurement error and the internal reliability of the examinations has room for significant improvement. The school lacks the resources and budget to build an examination with the rigor and psychometric stability of the NAPLEX or PCOA; however, this locally developed examination has proven to provide significant and useful data to improve the quality of the WUSOP program. The ASMA examination program is not universally employed, so it represents only one school’s result. However, given the level of scholarship developed to validate the ASMA program, there is strong evidence that this type of progress examination should be strongly considered as a valid assessment of student failure to demonstrate competence.

The PCOA is now a mandatory component in every pharmacy program’s assessment toolbox and must be administered to all students in their final semester of didactic education. It assesses only a selected subset of the curriculum, primarily Center for the Advancement of Pharmacy Education (CAPE) 2013 Domain 1, and provides no competency benchmark. The PCOA is norm-referenced and as such allows a student and a program to compare themselves to previous test takers on the foundational knowledge

required to pursue advanced practice experiences.⁷ As a criterion referenced examination tailored to the specific curriculum of the WUSOP program and benchmarked to a faculty-determined minimal competency score, the ASMA examinations attempt to assess whether or not a student is competent. Regardless of use of PCOA, programs will still need to develop evidence of student competence. The ASMA should be considered, along with objective structure clinical examinations and other assessments as ways a program can provide evidence of student competence. Standards 2016 requires the PCOA to be administered in the last semester of every student's didactic education. The results of this analysis suggest that the best time for administration may be earlier in the program. The P2 ASMA examination strongly identified candidates likely to fail and leaves sufficient time before the end of didactic instruction for remediation to be successful.

CONCLUSIONS

The Wingate University School of Pharmacy Annual Skills Mastery Assessment (ASMA) Exam is given to all pharmacy students each year and is built around grade-specific content and constructs that demonstrate professional competence. Scores from these examinations were strongly correlated to GPA and national licensing examination scores and weakly correlated to law examination scores. Regression analysis indicated a significant linear relationship between examination scores and both GPA and the licensing examinations. Students who performed poorly on the progress exams were more likely to fail the national licensing examination, more likely to fail to graduate on time, and more likely to earn a cumulative didactic GPA below 3.0. The P2 examination program strongly predicts students at risk for failure to graduate on time or achieve a GPA below 3.0, while all four examinations (P1-P4) identify students at risk of failing the national licensing examination on their first attempt. Thus, there is strong evidence that the ASMA examination program is a valid assessment of failure to demonstrate competency on the part of entry level PharmD graduates.

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Appendix 1. Individual Mastery Report for Sample Individual Student Report

Test: P4 2014 Final 2.0; Grade: M; Score: 78.4% (156.0 of 199.0)					
Objective	Mastery ^a	Score	% ^b	0	100
P1 Abilities	☺	41.0 of 45.0	91.1
Terminal abilities acquired by the end of P1 year					
Ability 9 Pharmacy Calculations	☺	9.0 of 10.0	90.0
Ability 26 Drug Mechanisms	☺	15.0 of 15.0	100.0
Ability 28 Biomedical Informatics	☺	9.0 of 10.0	90.0
Ability 33 Patient Counseling	☺	8.0 of 10.0	80.0
P2 Abilities	☺	40.0 of 54.0	74.1
Terminal abilities acquired by the end of P2 year					
Ability 60 Drug Pharmacokinetics	☺	14.0 of 15.0	93.3
Ability 62 Dosing Adjustment	☺	7.0 of 9.0	77.8
Ability 66 Patient Care Plan	☺	9.0 of 10.0	90.0
Ability 71 Clinical Labs	☹	4.0 of 10.0	40.0
Ability 87 Patient Therapy	☺	6.0 of 10.0	60.0
P3 Abilities	☺	32.0 of 38.0	84.2
Terminal abilities acquired by the end of P3 year					
Ability 147 Problem List	☺	10.0 of 10.0	100.0
Ability 148 Patient Care	☺	12.0 of 15.0	80.0
Ability 167 Therapeutic Outcomes	☺	10.0 of 13.0	76.9
P4 Abilities	☺	43.0 of 62.0	69.4
Terminal abilities acquired by the end of P4 year					
Ability 176 Patient Problem	☺	17.0 of 22.0	77.3
Ability 178 Adverse Drug Effects	☺	12.0 of 20.0	60.0
Ability 180 Dosage Adjustment	☺	6.0 of 10.0	60.0
Ability 184 Disease Differential	☺	8.0 of 10.0	80.0

^aSmiling faces indicate Mastery. Half frowning faces indicate Partial Mastery. Frowning faces indicate No Mastery

^bVertical black lines are visual representations of student's scores for each ability. Black bars are visual representations of minimal competency. A vertical bar to the right of a black bar indicates the student score indicates mastery

Appendix 2. Mastery Summary Report: P4 2014 Final 2.0 from Scores Spring 2014

Objective	#M	#PM	#NM	%M	%PM	%NM	PTS	HIGH	LOW	AVG
P1 Abilities	68	0	0	100.0	0.0	0.0	45.0	44.0	29.0	39.2
Ability 9 Pharmacy Calculations	68	0	0	100.0	0.0	0.0	10.0	10.0	7.0	9.1
Ability 26 Drug Mechanisms	59	5	4	86.8	7.4	5.9	15.0	15.0	6.0	11.8
Ability 28 Biomedical Informatics	66	2	0	97.1	2.9	0.0	10.0	10.0	6.0	9.1
Ability 33 Patient Counseling	67	1	0	98.5	1.5	0.0	10.0	10.0	6.0	9.3
P2 Abilities	68	0	0	100.0	0.0	0.0	54.0	51.0	31.0	43.5
Ability 60 Drug Pharmacokinetics	63	2	3	92.7	2.9	4.4	15.0	15.0	6.0	12.3
Ability 62 Dosing Adjustment	63	0	5	92.7	0.0	7.4	9.0	10.0	3.0	7.4
Ability 66 Patient Care Plan	67	0	1	98.5	0.0	1.5	10.0	10.0	4.0	8.4
Ability 71 Clinical Labs	47	17	4	69.1	25.0	5.9	10.0	10.0	3.0	7.2
Ability 87 Patient Therapy	64	4	0	94.1	5.9	0.0	10.0	10.0	5.0	8.1
P3 Abilities	68	0	0	100.0	0.0	0.0	38.0	38.0	25.0	33.4
Ability 147 Problem List	67	1	0	98.5	1.5	0.0	10.0	10.0	6.0	9.3
Ability 148 Patient Care	67	1	0	98.5	1.5	0.0	15.0	15.0	8.0	13.2
Ability 167 Therapeutic Outcomes	66	2	0	97.1	2.9	0.0	13.0	13.0	8.0	10.9
P4 Abilities	65	0	3	95.6	0.0	4.4	62.0	58.0	37.0	48.8
Ability 176 Patient Problem	64	4	0	94.1	5.9	0.0	22.0	22.0	13.0	17.0
Ability 178 Adverse Drug Effects	51	11	6	75.0	16.2	8.8	20.0	18.0	10.0	14.8
Ability 180 Dosage Adjustment	68	0	0	100.0	0.0	0.0	10.0	10.0	6.0	8.0
Ability 184 Disease Differential	66	1	1	97.1	1.5	1.5	10.0	10.0	5.0	8.9
Summary										
All Objectives	29	-	0	42.7	-	0.0	199.0	185.0	129.0	164.8
All Areas	65	-	0	95.6	-	0.0	199.0	185.0	129.0	164.8

#M=Number Mastering; #PM=Number Partial Mastering; #NM=Not Mastering; %M=Percent Mastering; %PM=Percent Partial Mastering; %NM=Percent Not Mastering. PTS=Possible Points; High=Highest Points; Low=Lowest Points; Avg=Average Points

Appendix 3. Annual Skills Mastery Assessment Exam Test Blueprint for 2014

Ability Set	Ability	P1 Test	P2 Test	P3 Test	P4 Test
P1 Abilities					
TABO #					
9	Perform a selected pharmaceutical calculation	12	10	10	10
22	Describe the various cellular processes essential for survival	12	0	0	0
23	Define the structure, nature, location, and function of a selected component of the human anatomy	12	0	0	0
25	Describe how the organs and organ systems function together to maintain various homeostatic variables	12	10	10	0
26	Describe the mechanism of action for a selected drug or drug class	25	10	10	10
28	Describe the appropriate use of primary, secondary, and tertiary medical literature, databases and Internet sites	12	10	10	10
33	Communicate selected counseling points	15	10	10	10
P2 Abilities					
TABO #					
60	Describe the fundamental elements and major factors that influence drug absorption, distribution, binding, metabolism, and excretion	0	10	10	10
62	Describe the influence of drug and patient characteristics on dosing	0	10	10	10
66	Create a plan to appropriately monitor/select drugs using drug concentrations and physiological effects	0	10	10	10
71	Recognize the clinical significance and implications of a given laboratory test result	0	10	10	10
87	Define a therapeutic goal for a selected patient	0	10	10	10
96	Detect the adverse drug effects associated with a selected drug regimen	0	10	10	0
115	Describe the major regulations that influence the practice of pharmacy in the state of North Carolina	0	10	10	10
P3 Abilities					
TABO #					
147	Create a problem list for a selected patient	0	0	10	10
148	Design a patient-specific care plan for a selected patient	0	0	15	15
167	Assess therapeutic outcome in a selected patient	0	0	15	15
P4 Abilities					
TABO #					
175	Define a drug and nondrug regimen for the resolution of the problem identified for a selected patient	0	0	0	10
176	Define an alternative course for the resolution of the problem identified for a selected patient	0	0	0	15
178	Detect adverse drug effects associated with a selected drug regimen	0	0	0	15
180	Recommend dosage adjustment for a selected drug regimen for a selected patient	0	0	0	10
184	Differentiate disease states based upon given symptoms in a selected patient	0	0	0	10
Item Count		100	120	160	200

TABO=Terminal Ability Based Outcomes Statement selected from the Wingate University School of Pharmacy List of TABO