Utility of the Pharmacy College Admission Test (PCAT): Implications for Admissions Committees

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The purpose of this study was to determine the value of the PCAT as a predictor of academic success and to provide a method for other institutions to use when evaluating predictors of academic success. Independent variables included all PCAT scores, prepharmacy GPA, math and science GPA, and attainment of a previous college degree. The dependent variable was cumulative professional first year GPA. Pearson product-moment correlations were generated for each data pair. Multiple regression was used to generate predictive models. The largest AdjR^2=0.452, P<0.01 was generated with the most complex model which included all independent variables. The most parsimonious model included math and science GPA and the chemistry subscore of the PCAT (AdjR^2=0.436, P<0.01). The PCAT was found to be a significant predictor of first-year pharmacy school performance. These methods can be generalized to other institutions interested in studying factors that may be significant predictors of academic performance.

INTRODUCTION

Schools of pharmacy strive to admit the most qualified applicants to their respective programs. The difficulty lies in identifying those applicants who will succeed in a pharmacy program. A measure of success in any school is academic performance. Any number of ways can be used to assess academic performance. These include semester grade point average (GPA), cumulative GPA, or grades in selected courses in a professional curriculum. Since 1998 (when the requirement was reinstated), the University of Arizona College of Pharmacy has been using the Pharmacy College Admissions Test (PCAT) as a tool in the admissions process. At that time, it was not known whether the PCAT added any new information about a particular applicant. The PCAT was developed by the PCAT subcommittee of the American Association of Colleges of Pharmacy (AACP) and The Psychological Testing Corporation jointly in an effort to measure verbal, quantitative, and scientific ability for students interested in pursuing a career in pharmacy(1). It was designed to predict success during the first professional year(2). In 1974, the exam was first administered to pharmacy school applicants for the fall 1975 entering class(1). Since that time, many studies have attempted to link PCAT performance to academic achievement. Research predicting first-year academic performance from admissions data has yielded varied results. Many of the studies that focused on the PCAT as a predictive tool were done in the 1970's shortly after the PCAT became widely used(3-10).

Cox and Teat were concerned that much of the past research done on the predictive ability of selected variables on GPA had focused on programs where there was a BS program or a BS program with a PharmD program. They investigated three classes (1990, 1991, 1992; all PharmD) at Campbell University. Their analysis examined the relationship between admission criteria and academic performance. Regression analysis yielded a significant model that included prepharmacy GPA and the biology subscore of the PCAT as predictors of academic performance R^2=0.42. They reported that prepharmacy GPA was the stronger of the two predictors. Their results indicated the predictive power of their model remained throughout the third professional year of pharmacy school(11).

In 1993, a "new" PCAT was implemented consisting of five areas: Verbal, Reading Comprehension, Quantitative Ability, Biology and Chemistry(12). This was in contrast to the "old" PCAT which consisted of seven areas: Reading Comprehension, Biology, Arithmetic Skills, Chemistry, Verbal Ability, Quantitative Ability, and Mathematical Reasoning(3). Chisholm, Cobb, and Kotzan conducted a study with the "new" PCAT at the University of Georgia College of Pharmacy. They found that the "new" PCAT did not predict academic performance in the first year of pharmacy school when gender was not taken into account. When gender was included as an independent variable, the verbal section and composite score of the PCAT were found to be significant for females. The strongest predictors overall were math and science prepharmacy GPA and obtaining a four-year college degree prior to pharmacy school(12). In a study conducted at the University of Arizona, College of Pharmacy, PCAT verbal ability scores were found to correlate with performance on a writing examination(13).

In a recent study at the University of Georgia College of Pharmacy, Chisholm, Cobb, and DiPiro aimed to determine which factors predict academic performance in the first year of pharmacy school. They defined two groups, an upper group and a lower group. The upper group included those students in the upper 25th percentile, based on GPA rankings, and the lower group consisted of all other students. These investigators examined prepharmacy GPA, PCAT scores, and whether the student had attained a previous four-year degree as potential predictors of academic performance in the first year of pharmacy

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school. They found both math and science GPA and attainment of a previous four-year degree to be the best predictors for students in the upper group. PCAT scores were not found to be predictors of academic performance. Their model was determined to be *96* percent accurate in predicting students in the upper group, while predictions of students in the lower group were found to be inaccurate in over two-thirds of the cases. They suggest other factors might predict academic performance for students in the lower group. Some of these factors might include the death of a family member, illness, financial hardship, and lack of support or bonding from faculty and friends. The authors conclude by stating that the PCAT may have a role in the admissions process by serving as a leveling effect for students that come from a variety of institutions. However, it has limited value in predicting first-year academic performance for students attending the University of Georgia College of Pharmacy(14).

Investigators at Texas Tech University Health Sciences Center School of Pharmacy studied factors thought to predict academic success. Variables included scores on the California Critical Thinking Skills Test (CCTST), prepharmacy GPA, cumulative GPA, PCAT scores, interview scores, and whether students took organic chemistry at a two or four-year institution. Significant predictors of first year pharmacy school academic performance included prepharmacy GPA, cumulative GPA, and PCAT scores, where correlation coefficients were 0.357, 0.380, and 0.199 respectively. These variables were also significant predictors for overall academic performance. These investigators also found the CCTST to be a significant predictor in two course sequences (management and behavioral sciences and clerkship courses). They also reported that the CCTST scores predicted scores on the PCAT, correlation coefficient 0.448(16).

All cited works attempted to find factors that predict academic performance. Prepharmacy GPA, prepharmacy math and science GPA, PCAT scores (composite and subset), and attainment of a previous college degree have all been found to have predictive power. Since each institution has different prepharmacy requirements, faculty, and curriculum, the question remains whether these factors will predict first-year academic performance at all schools and colleges of pharmacy.

This study was conducted to determine if the significant efforts put forth by faculty and students surrounding the PCAT were worth the information gathered by said examination. The primary objective was to determine the value of the PCAT as a predictor of academic performance in the first year of pharmacy school and provide recommendations to a specific College Admissions Committee. The methods employed in this study may be generalized to other academic institutions.

METHODS

The population studied was doctor of pharmacy students (PharmD) at the University of Arizona College of Pharmacy. Students from the graduating classes of 2002, 2003 and 2004 comprised the population of interest because they were required to take the PCAT as a condition for admission to the professional program. This research was deemed exempt by the Human Subjects Committee.

The independent variables of interest included all scores from the PCAT: Composite score, Verbal Ability, Biology, Reading Comprehension, Quantitative Ability, and Chemistry as well as cumulative prepharmacy GPA, math and science prepharmacy GPA, and attainment of a previous college degree. The dependent variable was first-year cumulative professional GPA. A data collection form developed for the purposes of this study did not contain any identifying student information. Correlational analysis was performed using the statistical software package SPSS v10.0 (SPSS, Chicago, IL). A Pearson product-moment correlation matrix was generated for each of the data pairs of interest. Multiple regression was used to determine which factor(s) produced the most predictive model of academic performance. The general form of the regression equation is given by the following:

Table I. Subject characteristics

Number of Students	159
Male	58 (36.5 percent)
Female	101 (63.5 percent)
Previous College Degree	60 (37.7 percent)
Average Age in Years	25.3 ± 5.06

$$\text{Predicted GPA Yr} = b + ß_1X_1 + ß_2X_2 + ß_3X_3 + \ldots + ß_nX_n \quad \text{(Eq. 1)}$$

where Predicted GPA Yr is the predicted GPA earned after the first professional year, ß is the intercept, $ß_1$, $ß_2$, $ß_3$, … $ß_n$ are the unstandardized regression coefficients for the predictive variables X_1, X_2, X_3, …, X_n. The squared multiple correlation coefficient (R^2) generated from the model is the proportion of variance explained by the variables included in the equation. The adjusted R^2 ($AdjR^2$) is a more accurate reflection of the true variance explained by the dependent variables. It takes into account the chance error added by each of the independent variables, as well as the sample size.

RESULTS

A total of 159 students from the classes of 2002, 2003, and 2004 were used for the data analysis. Table I shows the population characteristics of interest. A correlation matrix was generated using all pertinent variables (Table II). All data pairs were significantly correlated ($P<0.01$) with first year GPA. The strongest correlations with first year GPA were chemistry subscore of the PCAT (r=0.579), followed by the composite subscore of the PCAT (r=0.495), math and science prepharmacy GPA (r=0.478), and biology (r=0.416). The correlation between math and science GPA and first-year GPA is not surprising since the former is contained entirely within the latter. Other data pairs had correlation coefficients less than 0.400. Data from the correlation matrix was used to generate various models using multiple regression.

The data for the dependent variable (GPA Yr) were analyzed using Lilliefor's test for normality. These data were found to be normally distributed. All models met the statistical assumptions for multiple regression analysis(15). See Table III for selected models. Six of the models yielded $AdjR^2$ values accounting for more than 40 percent of the variance in the first-year GPA. Included were the most complex models (models one and two) in addition to models that contained as few as one independent variable. The most variance was accounted for by one of the most complex models, $AdjR^2$=0.452. A model that included three independent variables, math and science prepharmacy GPA, attainment of a previous college degree, and the chemistry subscore of the PCAT accounted for a similar amount of variance, $AdjR^2$=0.446. Using just two independent variables, the chemistry subscore of the PCAT and math and science prepharmacy GPA, the $AdjR^2$ (0.436) decreased by

just 0.016 (1.6 percent). A similar AdjR^2 (0.410) was generated from the model that used prepharmacy GPA and the chemistry subscore of the PCAT.

Greater than 50 percent of individuals that entered pharmacy school with a chemistry subscore on the PCAT of at least 50 attained a first-year GPA of 3.0 or greater. Similarly, more than 50 percent of students entering pharmacy school with a math and science GPA of at least 3.0 attained a GPA of 3.0 or more after their first professional year in pharmacy school. Nearly three-fourths of the population attained a first-year GPA of 2.5 when they had at least 50 on the chemistry subscore of the PCAT. Approximately 90 percent of students entering pharmacy school with a math and science prepharmacy GPA of at least 2.5 attained a first-year GPA of 2.5 or greater. When considering data from math and science GPA and attained first-year GPA or using the chemistry subscore of the PCAT and attained first-year GPA, a sample flow chart can be constructed for admissions committees (Figure 1). For each of the variable pairs, arbitrary breakpoints had to be made. GPA was separated into four divisions (x<2.0, 2.0=x<2.5, 2.5=x<3.0, or x=3.0, where x = math and science GPA or first-year GPA as appropriate). The chemistry subscore of the PCAT was separated into twenty divisions starting with 0-4 and ending with 95-100. These data were then analyzed to determine if a particular score or GPA could identify those students that may be successful academically during their first year of pharmacy school. There were clear breakpoints in the data. Admissions committees must define academic success (attained GPA's) which will determine the number of students captured for a given variable. A proposed flow chart (Figure 1) is included to show how this data could be incorporated into recommendations at specific institutions.

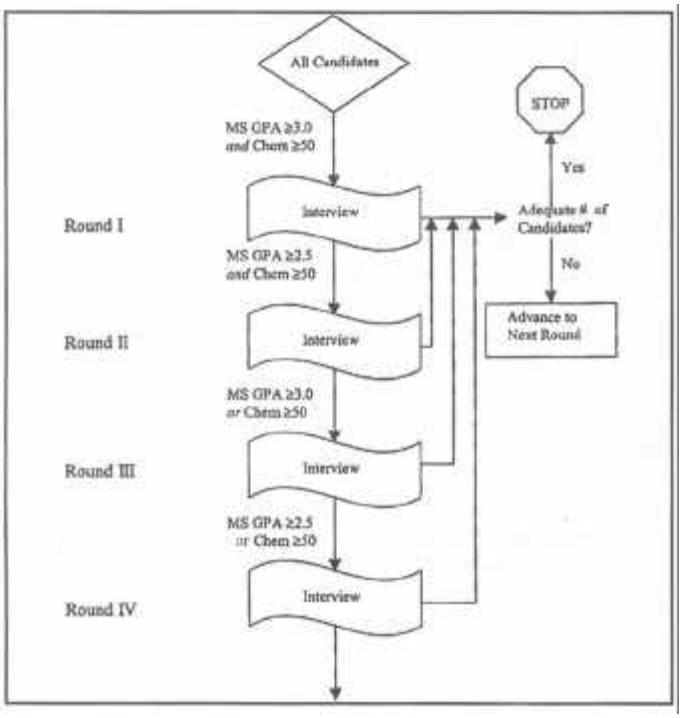

Fig. I. Use of the most parsimonious model: A proposed decision algorithm.

DISCUSSION

Results from previous investigators have been diverse and include scores from the PCAT(3,11), GPA(3,5,6,9-12,14,16), and attainment of a four-year college degree(12,14). Results from this investigation showed the PCAT to be a significant contributor in the prediction of academic success as measured by first-year GPA. All subscores were significantly correlated

Table II. Pearson correlation matrix

	Comp	Verbal	Biology	RC	Quant	Chem	GPA pre	MS GPA	GPA Yr
Comp	1.000	0.776*	0.702*	0.700*	0.585*	0.726*	0.074	0.229*	0.495*
Verbal		1.000	0.503*	0.600*	0.260*	0.336*	-0.007	0.057	0.218*
Biology			1.000	0.393*	0.174*	0.504*	0.122	0.218*	0.416*
RC				1.000	0.270*	0.356*	0.142	0.116	0.278*
Quant					1.000	0.440*	0.028	0.201*	0.389*
Chem						1.000	0.123	0.280*	0.579*
GPA pre							1.000	0.483*	0.364*
MS GPA								1.000	0.478*
GPA Yr									1.000

*P<0.01; Comp = PCAT Composite, Verbal = Verbal subscore, Biology = Biology subscore, RC = Reading Comprehension subscore, Quant = Qualitative subscore, Chem = Chemistry subscore, GPA pre = prepharmacy GPA, MS GPA = math and science prepharmacy GPA, GPA Yr = GPA after the first professional year.

Table III. Selected models for predicting first year academic success

Variables	Model #	R	AdjR^2
GPA pre + ped + Quant + Verbal + Biology + RC + Chem	1	0.675	0.431*
MS GPA + ped + Quant + Verbal + Biology + RC + Chem	2	0.690	0.452*
GPA pre + Chem + ped	3	0.652	0.414*
MS GPA + Chem + ped	4	0.676	0.446*
GPA pre + Chem	5	0.646	0.410*
MS GPA + Chem	6	0.666	0.436*
Chem	7	0.579	0.331*
Comp	8	0.495	0.240*
MS GPA	9	0.478	0.224*

*P<0.01 for the model; Dependent variable = GPA Yr; ped = previous college degree, Comp = PCAT Composite, Verbal = Verbal subscore, Biology = Biology subscore, RC = Reading Comprehension subscore, Quant = Qualitative subscore, Chem = Chemistry subscore, GPA pre = prepharmacy GPA, MS GPA = math and science prepharmacy GPA, GPA Yr = GPA after the first professional year.

Table IV. Results of regression analysis for model 6

Variable	?	*t*	Sig		
Constant	0.879	3.146	<0.01		
Chem	0.00965	7.763	<0.01		
MS GPA	0.472	5.504	<0.01		
	Sum of squares	**df**	**Mean square**	**F**	**Sig**
Regression	19.728	2	9.864	62.146	<0.01
Residual	24.761	156	0.159		
Total	44.490	158			

Dependent variable = GPA Yr; Independent variables Chem and GPA Pre, where Chem = Chemistry subscore and MS GPA = math and science prepharmacy GPA

with first-year GPA. It was not surprising that the chemistry subscore of the PCAT had the strongest relationship with first-year GPA since many classes in the first year have chemistry components (*e.g.,* biochemistry, pharmaceutics, and medicinal chemistry).

Models to incorporate combinations of variables have been reported in the literature which account for 28.6-64.3 percent of the variance in first-year academic performance(3,5,6,9,11). The most predictive models tended to employ a combination of variables including various PCAT subscores, attainment of a previous college degree, and prepharmacy GPA. This study found similar results for the predictive models of academic performance. The most complex model accounted for 45.2 percent of the variance for the first-year GPA.

The models that used only prepharmacy GPA, math and science GPA, or individual PCAT scores as individual predictors accounted for less than 30 percent of variance. When these independent factors are taken collectively, the predictive power of the model, increases remarkably (Table III).

Chisholm *et al.,* found both math and science prepharmacy GPA and attainment of a four-year college degree to be the most important predictors of academic performance(12,14). In contrast, attainment of a four-year college degree was not a significant predictor in the models generated in this study (Table III). One possible explanation for this is due to the varied backgrounds of students at the University of Arizona College of Pharmacy. Many students may be only a few credits shy of earning a four-year degree, and thus were not included as having attained a previous college degree. The number of college credit-hours may be a significant predictor, but these data were not collected as part of this research.

The most predictive yet the most parsimonious model should be used when attempting to evaluate a candidate for admission into an educational program. It was found that a model that contained just two independent variables could account for nearly 50 percent of the variation found in the first year GPA. The additional variance accounted for in each model must be considered as the model becomes more complex. The additional variance accounted for between the most parsimonious model (model six) and the most complex model with the highest $AdjR^2$ (model one) is only 1.6 percent. This difference is not likely to produce any meaningful benefits when identifying candidates for admission. The more complex models, however, are likely to complicate the decision making process. Model six uses both math and science GPA and the chemistry subscore of the PCAT. The pertinent values for this model are shown in Table IV. Using Eq. 1, the equation for this model, the predictive equation becomes:

Predicted GPA Yr = 0.879 + 0.00965*Chem + 0.472*MS GPA

where Predicted GPA Yr is the predicted GPA obtained after the first professional year, Chem is the Chemistry subscore of the PCAT, and MS GPA is the math and science prepharmacy GPA. From this data, conclusions can be drawn that the PCAT does have predictive ability on first year academic performance when taken together with performance in previous coursework. In practical terms, one must decide how to use results from the PCAT in determining its value as a tool in the admissions process.

There are several limitations of this study. Firstly, the GPA in prepharmacy coursework was not analyzed separately to determine if completing prepharmacy coursework at a two-year or a four-year institution made a difference with respect to success after the first professional year. A further limitation is the limited number of classes analyzed. The specific results obtained in this study may not be generalizable to other institutions, yet the methodology is.

Several assumptions were made with this study. First, it was assumed that each student invested ample study time, had proper sleep and nutrition and the testing atmosphere was conducive to taking the PCAT. Therefore, the score reported to the school (and subsequently the scores used in this study) were assumed to be the best possible score for each student. Furthermore, it was assumed that academic performance, that is, the GPA earned by each student represents the best performance that student was able to achieve.

Further studies will need to be conducted over a longer period to see if the same variables predict academic performance. Success through experiential rotations should also be examined to determine which variables have may have predictive power. Studies are also needed to test the actual predictive ability of the generated models in a prospective fashion. Further investigations in the area of decision algorithms should be done that develop criteria and threshold for admission. The study findings were presented to the Admissions Committee with a recommendation to maintain the current use of the PCAT as a screening tool for admissions to the University of Arizona College of Pharmacy.

CONCLUSIONS

The most parsimonious model included the chemsitry subscore of the PCAT and math and science GPA. These two variables should be used to screen and ultimately admit applicants that are likely to succeed in the first professional year. Those with chemistry subscores of at least 50 and math and science GPA's of at least 3.0 should be interviewed. Depending on the number of acceptable applicants, a second tier of potential candidates may be needed to increase the size of the pool. The criteria

for the second round may include chemistry subscore of at least 50 and GPA's of at least 2.5. Figure 1 contains a proposed flow chart that used the data gathered in this investigation. Since more than 40 percent of the variance was accounted for in the cumulative professional GPA after the first professional year with the chemistry subscore and the math and science GPA, these two variables should have an integral role in the decision for admission. The methods used in this study may be used to define criteria to identify those applicants that are likely to succeed academically at any school or college of pharmacy. The unique institutional data generated would provide objective data to aid in admissions decision making.

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