# RESEARCH ARTICLES

# Comparison of Two Lecture Delivery Platforms in a Hybrid Distance Education Program

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**Objective.** To compare students' preferences for and academic performance using 2 different distance education course content delivery platforms.

**Methods.** A randomized, crossover research design was used to compare traditional video with a 4-panel platform among learners on multiple campuses within 1 college of pharmacy.[1] The outcomes were students' preferences for delivery platform and examination scores. Rasch analysis was used to assess unidimensionality and the difficulty of examination items. Hierarchical logistic and multiple regression models were used to assess students' preferences and academic performance.

**Results.** The logistic model predicting preference for the 4-panel or traditional platform was not significant, but African-Americans and Hispanics were more likely to prefer the 4-panel platform than Caucasian and Asian students. The delivery platform did not impact students' academic performance. Students who did well on the semester's previous 2 examinations scored higher on the questions related to schizophrenia. Students with higher Pharmacy College Admission Test (PCAT) scores performed better on the bipolar questions than students who preferred the traditional video platform.

**Conclusion.** The additional faculty time, effort, and cost invested in presenting the class material in a 4-panel platform, and the students' extra time and effort spent viewing the 4-panel platform did not produce a comparable benefit in student preference and performance.

**Keywords:** distance education, academic performance, distance learning, educational technology, learning style, learning preferences, assessment

## INTRODUCTION

The pharmacist shortage in the United States is attributed to an inability to train new pharmacists at the same rate as the growth in demand for pharmacists.[1] Schools and colleges of pharmacy are pressured to graduate more students to lessen the gap between the supply and demand for pharmacists. The high cost of starting new pharmacy schools and the difficulties in finding qualified new faculty members have spurred exploration into options for training pharmacists. Some existing schools and colleges of pharmacy have increased their on-campus class size, while others have addressed space or resource constraints by employing distance education programs.

Video-based instruction is effective in distance education because students are able to view lectures at their own pace, instructions can be reviewed multiple times, class material is more accessible, and study time is spent more efficiently.[2-4] The lack of interaction with the instructor, however, is a disadvantage.[4] Nevertheless, distance-learning strategies have been adopted because they are effective and cost-efficient.

The best way of delivering content is equivocal. While studies have shown academic achievement is improved when instructors respond to students' different learning styles,[5] others have shown no difference.[6] Although students may have more than one learning style, they usually have a preferred style.[7] Thus, while students in the same class receive the same instruction, the teaching strategy used may be effective for some students and ineffective for others.

Multiple platforms are available to deliver content at a distance; however, not all platforms are equivalent with regard to students' learning.[8,9] Platforms can be more or less aligned with students' preferences.[10-12] Making the decision even more complex, not all delivery platforms cost the same to develop and deliver. Real costs are associated

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with faculty and programmer effort and time, and software and hardware requirements; however, more expensive platforms may be warranted if they also are more cost effective.

The College of Pharmacy at the University of Florida (UF) doubled enrollment by implementing a hybrid distance education program in August 2002.[3] The traditional video platform format has predominated since the inception of the program. It has been characterized as "a talking head with slides" and targets visual and audio senses. Lectures are digitally recorded at the Gainesville campus and video streamed via the Internet, enabling students to watch the lectures online within 2 hours. The content is the same for all 4 campuses, as are the teaching methodologies for all of the courses in the curriculum.

Depending on the course, the majority of students on the Gainesville campus also view the lectures via the video platform rather than attending the "live"/traditional classes.

As an alternative, the college experimented with a 4-panel format, an interactive multimedia platform designed to address students' different learning preferences and determine the most suitable method to deliver the courses' content to meet the needs of faculty members and students (Classroom 24/7, formerly DigiScript, Saddleback, NJ).

It consists of 4 panels appearing in 1 large window on the computer screen. The video and audio content are synchronized and appear in 1 panel. Transcripts of the lecture narrative, PowerPoint slides, and outlines appear in the other 3 panels. The 4-panel platform allows students to pinpoint and select specific content within a presentation by clicking on embedded outline links. Other organizational features include bookmarks, a search function, and handout tabs. Finally, the self-assessment quizzes with feedback embedded within the lectures offer students additional opportunities to interact with the course content and make self-assessments regarding whether they need to review a specific part of the lecture. These active-learning strategies are designed to enhance student learning.[13] These strategies are effective in live lectures[14] and some speculate they may be effective in Web-based courses.[8,15] The effectiveness of adding self-assessment questions and feedback to a content delivery platform are mixed.[16-19]

In fall 2005, both the traditional video and 4-panel platforms were employed in a second-year pharmacotherapy course. This pilot study compared students' preferences and academic performance using the 2 platforms. Our hypotheses were that students: (1) would prefer the 4-panel format, and (2) academic performance with the 4-panel format would be higher.

## METHODS
### Study Description

This pilot study used a randomized crossover research design (Figure 1). It was conducted during the psychiatry segment of the second-year pharmacotherapy course. To ensure students were exposed to both platforms before being randomized into a study group, the first 2 topics covered in the course were delivered to all students using the same format. First, 2 lectures on the treatment of depression were presented to all of the students using the 4-panel platform. Next, lectures on the treatment of anxiety were presented via the traditional video platform. The students were exposed to the 4-panel platform prior to the study to lower the learning curve associated with new technology. The anxiety lectures were delivered in the traditional format after the 4-panel format and before randomization to serve as a quasi-washout time period.

Following these common lectures, students in each of the classes at the College's 4 campuses were randomly assigned to 1 of 2 groups. Students in one group received 2 lectures on the treatment of bipolar affective disorder via the traditional video platform, while students in the other group received the same lectures via the 4-panel video platform. Next, students on the campuses that received traditional video platform of the bipolar lectures received 4-panel presentations for the treatment of schizophrenia; while students who had previously received the 4-panel bipolar presentations received the schizophrenia lectures via the traditional video platform. Students were told beforehand that the 4-panel platform was going to be tested on more than 1 occasion to see which delivery method they preferred, and that at least 2 disease topics would be in the 4-panel format, but they were not told which topics or when. The lecturer and course content were exactly the same and both groups of students viewed exactly the same video and audio portions of the lectures in both platforms.

### Outcome Variables

**Examination scores on relevant content.** Students' learning was assessed using 13 items embedded in the
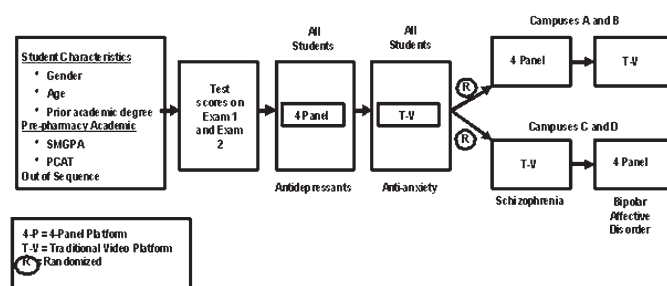


Figure 1. Design of a research study comparing two lecture delivery platforms for a hybrid distance education program.

third examination of the semester to test the material presented postrandomization. The examination questions pertaining to the psychiatry lectures were identified by the course coordinator. Five items were included for the depression and anxiety lectures, but were not included in the students' examination score outcome measure because all students received this material using the same delivery platform to reduce confounding.[1]

Students' total examination scores were obtained by summing the value of the logits for individual students on the 8 remaining items.[20] Individual students' logit scores for the 4-panel items were compared to the logit scores for the traditional video platform items. The examination also consisted of an additional 37 items covering thromboembolic disorders, Alzheimer's, attention deficit hyperactivity disorder, obesity, and insomnia.

**Preference for lecture video presentation.** Students' preferences for the lecture platforms were assessed via 2 questions embedded within an Internet-based survey administered at the end of the semester. Students were contacted by e-mail and offered extra credit points to complete the Internet-based survey instrument.

Students were asked, "Which of the following statements most accurately describes your preferences regarding the video presentations?" Students expressed their preferences by choosing 1 of 3 options: I preferred the 4-panel platform (+1); I have no preference between the 4-panel platform and the traditional video platform (0); or I preferred the traditional video platform (−1). Students were asked to report how much they preferred the chosen video platform using a Likert scale. The categories were: (1) just a little more, (2) somewhat more, (3) a lot more, or (4) it was the best. The value assigned to the preference category was multiplied by the degree of preference choice so scores ranged from −4 to +4.

Finally, students were asked to state whether they strongly agreed, agreed, were neutral, disagreed, or strongly disagreed with the statement, "I think that I learned the material better when I used the 4-panel platform compared to the regular video streaming." Students also were asked to identify the most helpful features of the 4-panel platform.

### Predictor Variables

**Lecture delivery platform.** The primary predictor in this study was the course content delivery platform. DigiScript randomized the delivery order and assignment of the campuses to the platforms (Classroom 24/7, formerly DigiScript, Saddleback, NJ). The investigators and students were blinded both to the campuses and the order in which the platforms were delivered. Randomization was not revealed until all of the data were collected.

The primary differences between the 2 platforms were embedded within the enhanced features of the 4-panel platform. Multiple-choice questions were periodically embedded as part of the 4-panel format. Students were required to answer the questions correctly before moving forward with the rest of the content. Students received feedback regarding their response to the question immediately upon submitting the answer.

**Covariates.** Covariates associated with academic success were added to the model.[3,21,22] Students' demographic characteristics included age, gender, and race (Caucasian, African-American, Hispanic, Asian, and other). Indicators of preadmission academic achievement included earning a bachelor's degree prior to admission to the pharmacy college (1 = yes, 0 = no), science/math grade point average (GPA), and percentile scores on the PCAT. Two measures of students' current academic performance included in the models were the sum of their scores on the first 2 examinations of the semester in the same course and whether they were "out of sequence" with the rest of their academic class (1 = yes; 0 = no). Out of sequence students were those with academic difficulty or who were behind in the curriculum for personal reasons.

### Statistical Analyses

The bivariate relationships between students' characteristics, preadmission academic performance, examinations scores, and platform preference were examined using Pearson's chi-square tests for categorical variables and independent *t* tests for continuous variables.

Hierarchical logistic regression models were fit to predict students' preference for the 4-panel or traditional lecture delivery platform. If the chi-square statistic for the change in the -2 log likelihood value was significant, the prediction of the students' probability of preferring the 4-panel delivery platform over the traditional delivery platform was improved.

A 1-parameter item response (Rasch) model was used, which is based on a probabilistic model that orders items and subjects simultaneously using maximum likelihood estimation.[20] The result arranges items along a difficulty continuum and subjects along an ability continuum.[23] Rasch analysis was performed using WINSTEPS, Version 3.31 (WINSTEPS, Chicago, IL). WINSTEPS provides detailed statistics for each item and the overall instrument. We used the default rating scale model with groups equal to 1 which assumes all of the items share the same underlying rating scale structure. We used it as originally conceptualized for use with dichotomous items[23] scored as correct or incorrect. Item difficulties and person measures are mapped in logits or log-odds units along the same linear continuum.

Rasch models also provide statistical results regarding items' unidimensionality and hierarchical ordering. Unidimensionality refers to whether the instrument measures a single construct.[24] Mean square standardized residuals (MnSq) and standardized Z scores identify how well each item fits the hypothesized unidimensional construct. For low-stakes multiple-choice questionnaires, a reasonable MnSq value is ≤ 1.3 or 30% variance.[24] Items > 1.3 "diverge unacceptably from the expected ability/difficulty pattern".[24(p26)] In addition to MnSq statistics, ZSTD estimates the improbability of participant responses. Items with Z scores of 2 or higher are considered too unpredictable.[25] Items exceeding both the MnSq and ZSTD criteria (MnSq ≥ 1.3 *and* ZSTD ≥ 2.0) were considered "misfitting."[24]

Item hierarchy orders items sequentially from least to most difficult. A student's ability is measured by logits, derived from transforming ordinal data into an interval scale. A student's position on a unidimensional scale is evaluated by ordering item difficulty and person ability on the same linear continuum. Students' raw scores can be misleading if items are not in a logit scale and hierarchical order. For example, if 2 students receive identical raw scores on a test, they do not necessarily have the same level of ability since one student may have correctly answered more of the most challenging items.[24]

Two measures of academic performance were examined using linear regression models: (1) students' scores on the 2 previous examinations, and (2) the sum of students' logit scores on the test items representing learning on the postrandomization materials. In each case, the demographic and prepharmacy academic variables were first added to the model. Next, the predictor variables (ie, lecture delivery platform) were added to the equation. Significant change in the coefficient of determination ($R^2$) indicates improvement in prediction of students' academic performance.

The study was conducted according to the principles of the Declaration of Helsinki. The University of Florida Institutional Review Board approved the study protocol. The *a priori* level of statistical significance was set at ≤0.05. SPSS was used to conduct the statistical analyses (SPSS for Windows, version 15.0, Chicago, IL.)

## RESULTS

### Description of the Sample

Three hundred twenty-eight students were enrolled in the class and 65% was female. Students' average age was 25.8 years (range, 19 to 53 years); their average prepharmacy science and math GPA was 3.4 ± 0.3; and their average maximum composite PCAT score was 86.9 ± 12.3. The majority (69.2%) of the students were white,

19.2% were Asian, and 11.6% were African-American, Hispanic, or other. The majority (45.7%) attended the Gainesville campus; other students attended the Jacksonville (16.2%), Orlando (16.8%), or St. Petersburg campuses (21.3%). One hundred twenty-four (37.7%) of the students had earned at least a bachelor's degree before admission.

Next, we compared students' demographic characteristics and prerandomization academic performance according to platform presentation order. On average, the students who viewed the 4-panel platform first were older (Table 1). This difference in age among participants was an unavoidable result of the prerandomization process for the Gainesville campus students, who were assigned to watch the traditional video first, were younger on average and represented nearly 40% of the College's student body. They were also more likely to have earned a bachelor's degree and had a lower average composite PCAT score before admission. However, the average prepharmacy science and math GPA, proportion of out-of-sequence students, race, gender, and average on the first 2 examinations of the semester in the class were similar. Demographic data were incomplete for 3 students, so they were excluded.

### Predictors of Academic Performance on Examination 1 and Examination 2

Female students scored between 4 and 5 points higher than male students. African-American and Hispanic students, and those students who indicated their race was "other" scored nearly 7 points lower than Caucasian students, and increasing age was associated with lower scores on examination 1 and examination 2 (Table 2). Examination scores were higher among students with higher science/math GPA and PCAT scores. Students earning a bachelor's degree prior to admission also scored nearly 4 points higher on the 2 examinations. When the variable representing the lecture presentation platform was included in the model, the overall model remained significant ($p < .001$). However, neither the unstandardized regression coefficient representing the platform variable nor the model's $R^2$ change was significant.

### Unidimensionality and Hierarchy of Examination Items

The items on the third examination showed acceptable unidimensionality, except for the anxiety 2 and schizophrenia 1 items. The standardized Z score for the anxiety 2 item was too high. Anxiety 2 and schizophrenia 1 items were the hardest and easiest question to answer, respectively. Item presentation order did not significantly influence the 95% confidence interval. The only item

Table 1. Demographic Characteristics and Academic Performance According to the Platform Delivered First After Randomization (N = 328)

| Demographic Characteristics and Achievement | Traditional Platform (n=203) | 4-Panel Platform (n=125) | P |
|---|---|---|---|
| Male (n = 116), No. (%) | 69 (34.0) | 47 (37.6) | 0.59 |
| Female (n = 212), No. (%) | 134 (66.0) | 78 (62.4) | |
| Age, years (SD) | 24.5 (4.3) | 27.8 (6.4) | <.001 |
| Prepharmacy SMGPA (SD) | 3.4 (0.3) | 3.4 (0.4) | 0.67 |
| Average PCAT composite score | 88.0 (11.1) | 85.18 (14.0) | 0.04 |
| Bachelors degree or higher (n = 124), No. (%) | 66 (32.5) | 58 (46.4) | 0.02 |
| Race | | | |
| White (n = 227), No. (%) | 141 (69.5) | 86 (68.8) | 0.61 |
| Asian (n = 63), No. (%) | 41 (20.2) | 22 (17.6) | |
| African-American, Hispanic, Other (n = 38), No. (%) | 21 (10.3) | 17 (13.6) | |
| Out of sequence, No. (%) | 19 (9.4) | 20 (16.0) | 0.10 |
| Score on examination 1 | 80.7 (11.4) | 78.7 (10.3) | 0.13 |
| Score on examination 2 | 78.5 (11.0) | 76.6 (9.8) | 0.12 |

Abbreviations: SMGPA = science and math grade point average
[a] Chi-square with Yates discontinuity Correction, 1 degree of freedom.
[b] Pearson chi-square.
[c] *t* test

outside of the 95% CI of the error of the items in the presented order was bipolar 2.

When the test items were arranged from easiest at the bottom to most difficult at the top, less than 20 students scored less than the mean for item difficulty. The mean of the students' ability level was approximately 1½ logits above the mean of the item difficulty, indicating that more than 90% of the students were able to correctly answer test items of average difficulty.

**Platform Preference**

Students' platform preference was investigated as a plausible explanation for scoring well or poorly on the post-randomization examination items. Nearly 84% (n = 273) of the 325 eligible students responded to the end of the semester survey. Nearly 75% of these students (n = 201) opined that the 4-panel platform was easy to use. Just over 51% of them (n = 140) preferred the traditional video platform, 100 (36.6%) preferred the 4-panel

Table 2. Predictors of the Sum of Examination 1 and Examination 2 Scores

| Variable | Step 1 | | Step 2 | |
|---|---|---|---|---|
| | Beta | P | Beta | P |
| Female Gender | −.12 | 0.02 | −.12 | 0.02 |
| Black | −.11 | 0.03 | −.11 | 0.03 |
| Asian | −.03 | 0.55 | −.03 | 0.55 |
| Age | −.25 | <.001 | −.25 | <.001 |
| SMGPA | .24 | <.001 | .24 | <.001 |
| PCAT | .23 | <.001 | .23 | <.001 |
| Yes, Bachelors Degree | .11 | 0.05 | .11 | 0.05 |
| Out of Sequence | .11 | 0.04 | .11 | 0.04 |
| Lecture Platform | NA | NA | −.01 | 0.81 |
| Adjusted $R^2$ | 0.19 | | 0.19 | |
| Model F-Ratio | 9.27 | | 8.65 | |
| Degrees of freedom | 8,316 | | 9,315 | |
| Model *p* value | <.001 | | <.001 | |
| F-Ratio of Change | | | 0.06 | |
| Degrees of freedom | | | 1,315 | |
| p-value of change | | | 0.81 | |

Abbreviations: *P* = alpha error (*p* value); Beta = Standardized OLS Regression Coefficient; SMGPA = Science and Math Grade Point Average; PCAT = Composite Score on the Pharmacy College Admission Test.

presentation platform, and 33 (12.1%) indicated no prefer-ence. When asked which feature was most helpful, 58.1% responded the ability to print the lecture narrative, while 25% responded the self-assessment and feedback feature. The remaining 4-panel features accounted for a small pro-portion of the remaining responses, including the lecture slides (5.9%), key word search features (3.3%), embedded outline (2.6%), notes (1.8%), and bookmarks (0.7%).

Most (40.1%) of the students were neutral regarding whether they learned better with one platform than the other; however, 28.3% opined they learned better with the 4-panel platform and 31.6% stated they learned better with the traditional video platform. Contrary to conven-tional wisdom, which would be that students would learn better using their preferred platform, students who thought they learned more using the 4-panel platform were more likely to prefer the traditional video platform (51.1%). Those who thought they learned more using the traditional video platform were more likely to prefer the 4-panel platform (62.0%), and those who were neutral about their learning were more likely to be neutral about their platform preference (60.6%; $p < 0.001$).

The logistic model predicting students' platform pref-erence was not significant. Race was the single significant variable. African-Americans, Hispanics, and other races were nearly 3 times more likely to prefer the 4-panel platform compared to Caucasian students. The findings were the same for the ordinary least squares regression and are available from the authors upon request.

### Comparison of Students' Academic Performance According to Delivery Platform

The average logit scores on the examination items were 4.5 ± 3.3 and 1.3 ± 1.5 for the schizophrenia and bipolar questions, respectively. The average difference in the logit and raw scores between the 2 presentation for-mats were similar (schizophrenia logit score = 4.6 ± 3.2 vs. 4.4 ± 3.4, independent $t$ test$_{(323)}$ = 0.53, $p = 0.59$; bipolar logit score = 1.4 ± 1.5 vs. 1.2 ± 1.5, independent $t$ test$_{(323)}$ = 1.06, $p = 0.29$.

Consistent with the bivariate findings, the delivery platform did not have a significant impact on students' academic performance after controlling for the covariates. Students who received the course content on the 4-panel platform scored < 1 point higher than those who received the content using the traditional video platform for both topics combined. Gender, race, age, prepharmacy science/ math GPA, PCAT score, prior BS degree, and whether the student attended one of the distance campuses or the Gain-esville campus did not influence academic performance.

Students who did well on the semester's previous 2 examinations scored higher on the questions related to schizophrenia (Table 3). The raw logit scores on the schizophrenia questions were impacted the most among students who were ''out of sequence,'' averaging 1.29 logits lower (95% CI = 0.09, −2.66) than students who were on track within the college's curricular sequence. On the bipolar questions, students with higher PCAT scores performed better (Table 3). Students who preferred the traditional video platform scored lower than students who expressed no platform preference. Students who preferred the 4-panel platform also scored lower than those with no preference, and students with higher previous examina-tion scores scored higher. The same relationship and pat-tern of results was seen for academic performance and platform preference for the schizophrenia course content, but it was not significant.

### DISCUSSION

The specific hypotheses of this pilot study were (1) students would prefer the 4-panel format because of the multiple learning styles involved, and (2) the academic performance of students assigned to the 4-panel format would be better than that of students using the traditional format. This finding was initially surprising because the 4-panel platform was designed to appeal to more learning styles. Upon reflection, we identified several possible explanations. In a study of medical students, approxi-mately 36% preferred receiving course-related informa-tion using only 1 learning style, including when asked to choose among visual (learning from graphs, charts, flow diagrams), auditory (learning from speech), printed word (learning from reading and writing), or kinesthetic (touch, hearing, smell, taste, and sight). However, nearly 64% preferred using 2 or more learning styles.[26] The tradi-tional video platform already combined visual and audi-tory learning to engage students. The 4-panel platform added kinesthetic learning in the form of questions and feedback, and the printed word in the form of transcrip-tions of the lecture. Although the 4-panel platform was used to present 2 lectures (1 topic) to all students before the campuses were randomized, students were more fa-miliar with the traditional video platform. The traditional video format had been used the entire previous year and during the current semester, with the exception of the pilot lectures. Some students may have had difficulty adapting to less familiar methods of instruction.[27] Perhaps it should have been more surprising that nearly 40% of the students preferred the 4-panel platform. Next, central to the prin-ciples of ''instructional preference'' is the notion of how individuals prefer to learn, whether through lectures, in-dividual study, or small-group studies. The 4-panel plat-form included neither small group studies nor live interaction with the instructor. For those who preferred

Table 3. Predictor of Students' Schizophrenia and Bipolar Logit Scores on Examination 3 (n = 269[a])

| Predictor Variable | Schizophrenia | | | | Bipolar | | | |
|---|---|---|---|---|---|---|---|---|
| | Step 1 | | Step 2 | | Step 1 | | Step 2 | |
| | Beta Coeff | *P* | Beta Coeff | *P* | Beta Coeff | *P* | Beta Coeff | *P* |
| Female Gender | .05 | 0.46 | 0.04 | 0.51 | -0.04 | 0.55 | -0.05 | 0.44 |
| Non-white Race | -0.02 | 0.72 | -0.02 | 0.72 | -0.05 | 0.47 | -0.04 | 0.55 |
| Age | -0.11 | 0.12 | -0.10 | 0.15 | -0.03 | 0.72 | -0.01 | 0.89 |
| Out of Sequence | -0.12 | 0.09 | -0.12 | 0.07 | 0.07 | 0.32 | 0.05 | 0.44 |
| SMGPA | -0.03 | 0.70 | -0.03 | 0.65 | 0.16 | 0.02 | 0.15 | 0.03 |
| PCAT | 0.07 | 0.28 | 0.07 | 0.27 | 0.09 | 0.21 | 0.09 | 0.18 |
| Yes, Bachelor's Degree | 0.08 | 0.21 | 0.07 | 0.26 | -0.01 | 0.91 | -0.03 | 0.71 |
| Total Exams | 0.23 | 0.001 | 0.23 | < .001 | 0.11 | 0.09 | 0.12 | 0.07 |
| Order Presented | 0.11 | 0.20 | 0.12 | 0.17 | -0.02 | 0.80 | -0.01 | 0.91 |
| Distance Campus | -0.03 | 0.75 | -0.04 | 0.65 | 0.02 | 0.82 | .01 | 0.94 |
| Traditional Preference[b] | NA | NA | -0.12 | 0.19 | NA | NA | -0.26 | .008 |
| 4-Panel Preference[b] | NA | NA | -0.07 | 0.47 | NA | NA | -0.19 | 0.06 |
| $R^2$ | 0.12 | | 0.12 | | 0.06 | | 0.09 | |
| Model F-Ratio | 3.43 | | 3.02 | | 1.72 | | 2.06 | |
| Model p-value | < .001 | | .001 | | 0.08 | | 0.02 | |
| $R^2$ Change | NA | | .007 | | NA | | 0.03 | |
| F-Ratio Change | NA | | 0.97 | | NA | | 3.61 | |
| p-value of change | NA | | 0.38 | | NA | | 0.03 | |

Beta Coeff = Standardized Regression Coefficient; t = value of t-test of the unstandardized regression coefficient; Sig = Statistical Significance of t-test of the unstandardized regression coefficient; SMGPA = Pre-admission Science and Math Grade Point Average; PCAT = Composite Score on the Pharmacy College Admission Test; $R^2$ = Coefficient of Determination.
[a] Number of students differs from students in the class because of students who did not complete the follow-up, semester end survey (n=56).
[b] Reference category is "no preference"

more personal interactions, the 4-panel platform was basically no different than the traditional video platform.

Lastly, the most frequently cited benefit of the 4-panel platform was the word-for-word transcription of the lecture rather than the questions and feedback feature. Conversely, the most frequently voiced objections were that: (1) it took longer to complete the lectures because they had to answer the questions and read the feedback, and (2) they could not "speed up" the lectures as they had been able to do with the traditional platform. Although this comment is largely speculative, the extra time it took students to complete the questions and feedback in the 4-panel format may have been a cost that some felt did not benefit them enough to make it worthwhile. Given the relatively small benefit gained in their examination scores, students' preference may be justified. Future work should look at students' motivations for learning and concordance of the platform features with those motivations. For example, both of the most frequent objections to the 4-panel platform were features that increased the amount of time it took students to complete course content.

The second hypothesis predicted that students' academic performance would be better on the material pre-sented using the 4-panel platform. Students' academic performance was not improved using the 4-panel platform. Theoretically, teachers can improve learning by adapting learning tasks and teaching methods to students' preferences.[28] The 4-panel platform added a downloadable transcript of the lecture that students could read, in addition to the self-assessment and feedback opportunities. In both cases, the students scored marginally higher with the 4-panel platform, but our findings did not corroborate studies that demonstrated self-assessment questions and feedback improved students test scores.[13] We did not have a direct measure of the learning styles; therefore, we assumed that the features added more learning styles to the 4-panel platform. However, while more learning styles may have been incorporated, they may not have aligned with students' preferred learning styles any better than the traditional platform.

The hypothesis that students' actual performance in the course was related to their preferred content delivery platform was partially supported and, surprisingly, opposite to our expectations. Students may have a preference for a specific platform, but it may have little influence on performance.[29,30] Conventional wisdom suggests that

adapting instruction to students' preferred learning styles should improve their academic performance. However, the literature is mixed and learning preference and learning styles are not consistently associated with academic performance.[17-19,31] In one study, significant improvement in performance did not persist after a delay of several months, although learning platform differences were seen immediately after the training.[15] One plausible explanation for our finding of no difference is that testing occurred 2 weeks after the lectures were presented. While 2 weeks seem to be a short time, factors associated with short- and long-term knowledge retention are not well understood.[32,33] Contradictory to our hypothesis, we found that objective measures of academic performance (ie, examination scores) were diametrically opposed to students' own perceptions of how much they learned.

Students' demographic characteristics were hypothesized to be associated with platform preference and academic performance. In some studies, students' preferences for learning strategies and outcomes were associated with personal and contextual factors, such as academic discipline, prior education, age, and gender,[21,22] but not in other studies.[15,26,34,35] Demographic characteristics played a small role in our comparison of the 2 platforms, with the exception of race. Both preference variables examined in this study showed that African-Americans, Hispanics, and racial groups other than Asian were significantly more likely to prefer the 4-panel platform compared to Caucasian students. While demographic characteristics (eg, age and gender) have been shown to be predictors of success in pharmacy school, our findings only partially support other studies that showed science/math GPA and past academic performance (eg, examination scores and maintaining adequate progress in the curriculum) may be among other predictors.[3,21,22] We based this observation on the fact that students in the 2 platform groups performed equally well on the first 2 examinations of the semester ($<$ 2% difference on each of both examinations). While many of these variables predicted students' total scores on examination 1 and examination 2, it was their performance on these 2 examinations that predicted students' scores on the items testing the postrandomization course material. This finding indicates these demographic and prepharmacy academic achievement factors did not directly impact postrandomization academic performance between the 2 platforms. Rather, they were mediated by students' performance on the current semester's course (Figure 1). Moreover, after both the platform and preference variables were added to the model, the coefficients representing the impact of the demographic and preference variables remained nearly identical. So, it seems that de-

mographic characteristics and the delivery platform's impact on students' academic performance is independent from their lecture platform preference. In fact, students' perceptions about which platform helped them learn better were opposite to their preference and those with no preference scored better.

**Limitations**

Interpretation and incorporation of these findings should only be done within the context of its limitations and should be considered in the design of any future work into educational programs. Individual students on the same campus viewed the lectures within the same format. We have no evidence they were aware that the platform was different among the campuses for the postrandomization schizophrenia and bipolar lectures. We think students were successfully desensitized to the experiment by providing washout lectures using the traditional video format before randomizing campuses to platform and by providing them with the same video of the same lecturer in both platforms. Therefore, the primary differences between the 2 platforms were the quizzes, feedback, and printed lecture transcript.

Randomization was not individual student based, but rather campus based. Therefore, biased findings and misinterpretations may have resulted from the ecological fallacy.[36] That is unlikely, however, since 2 campuses randomized into the same intervention group differed on their content delivery platform preferences.

The finding of a nonsignificant difference in academic performance also may be because the intervention was not strong enough or may have been underpowered. Both platforms had the same lecturer on the screen and the same audio narrative. The additional transcription, embedded questions, and feedback may not have been sufficient to impact their preference or their performance. Another platform with different features may have been a better venue to show learning differences. In other cases, the findings may have been underpowered because of the small sample size of the comparison groups. For example, the alpha error for students out of sequence (n = 39) was $p = 0.07$ for step 2 in Table 3, but the magnitude of the regression coefficient revealed that it had the second largest impact on students' performance on the schizophrenia questions. A similar situation occurred with the comparisons of the traditional and 4-panel platforms with those with no preference (n = 33) for the bipolar questions. Even so, this study was a legitimate evaluation of 2 different commercially available platforms, which was our original goal. If the obtained difference in academic performance were replicated over the typical 100-point examination, it would have made $<$ 2% difference in the

average student's total score. These findings were especially useful for decision-making purposes since the 4-panel was significantly more costly to deliver and the College continued to use the traditional video format.

We were unable to include more questions in the test of the outcome and unable to psychometrically test the questions embedded in the course's third examination in advance. The variability in the outcome was also limited because 1 of the post-randomization items was answered correctly by almost everyone. The schizophrenia and bipolar questions were only 16% of the third examination because the rest of the topics presented during the semester (eg, sleep products, stimulants) were tested in the same examination. In addition, 10% of the items tested the depression content of the first 4-panel lecture and the anxiety content within the washout video. Therefore, nearly three-fourths of the examination questions were unrelated to the trial. While not optimal, the conditions in this study showed that a legitimate demonstration of a randomized trial is possible in academic and scholarly research.

While this study has limitations, it has important strengths in comparison to most pharmacy educational interventions. First, it is a cross-over design where students serve as their own control; significantly increasing the power of the study. Campuses were randomized and students and researchers were unaware of assignment until after the course concluded. The 2 platforms and test items also were delivered within the everyday educational process of the college, rather than presenting the students with a special test of the content, as is the case with most studies of educational interventions. Finally, all of the students were initially introduced to the learning platform at the same time before the measured questions. The original format was also added so that it might washout the after effects of any platform-specific learning difficulties with the first exposure to the new platform. The washout strategy appeared to work because the difference in learning effect size was approximately equal and independent of the order in which the 4-panel platform was presented.

## CONCLUSIONS

Pharmacy students' academic performance was not significantly impacted by whether lectures were delivered using a traditional or 4-panel learning platform. The extra faculty time, effort, and cost put into presenting the class material in a 4-panel platform, and the students' extra time and effort required to review the material, did not produce a comparable benefit in student preference and performance. Factors other than the platform technology were more important in influencing students' preference and academic performance. Students' perceptions were in opposition to the conventional wisdom; namely, students

who preferred the traditional video format thought they learned better with the 4-panel platform and those who preferred the 4-panel platform thought they learned better with the traditional video format.

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