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Enrollment Forecasting for an Upper Division General Education Component

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Abstract – **An administration-engineering partnership was established to ensure the effective operation of an upper division, general education theme requirement at Grand Valley State University (GVSU). The percent of theme course seats occupied was increasing each semester and approaching 100%. Student complaints about course unavailability and other anecdotal evidence supported the quantitative evidence. A regression analysis, based on historical enrollment data, provided an accurate forecast of the number of students enrolled by semester and level, freshman through senior. A second regression analysis yielded equations for the number of theme courses taken by students at each level in each semester. The coefficient of determination (R^2) was 94.5% or above for each semester for juniors and seniors who are the vast majority of students in theme courses. Since resources for expanding theme courses offerings by the forecasted 23% were not available, existing courses were reviewed for their applicability to each theme and numerous of these were added for the 2005-2006 academic year. Academic year 2006-2007 theme courses enrollment is 93% of capacity. The number of student complaints concerning theme course unavailability is perceived to have dropped.**

Index Terms – Enrollment forecasting, institutional data analysis, general education

INTRODUCTION

The modeling and analysis techniques of operations research including statistical analysis, mathematical optimization, and simulation have long been applied to a wide variety of industrial and service system settings. Applications involving scheduling, capacity planning, justification for capital equipment acquisitions, and inventory management are common.

However, applications of operations research in university administration have been surprisingly rare. Fraser, Djumin, and Mager [1] discuss the application of Markov chain models to forecasting undergraduate enrollment. Racioppo [2] used simulation to investigate the impact of alternative policies on student persistence at a small liberal arts college.

This paper presents a case study concerning a justification of additional enrollment capacity in the upper division component of the general education program at Grand Valley State University (GVSU). Forecasting of both total student enrollment as well as the student demand for seats in these courses was done using regression analysis. The forecasting results were used to determine the magnitude by which student demand exceed course capacity. This analysis and subsequent discussions led to new policies concerning which courses could be used to meet the upper division general education requirement.

The situation which gave rise to the need for the analysis will be presented. The development and implementation of the resolution to the situation will be discussed. The subsequent validation of the solution will be shown.

THEME COURSES AND THE SHORTAGE OF SEATS

Beginning with the fall 2000 freshman class, all students at GVSU are required to complete an upper division (junior – senior level) general education requirement called the themes. A theme consists of a set of courses devoted to a particular topic such as:

- Creativity – Ideas and Innovation
- Earth and Environment
- Ethics
- Religion
- Sport and Life

Within each theme, courses are offered by a wide variety of departments. For example, courses in the Creativity – Ideas and Innovation theme are offered by:

- Economics
- Engineering
- Liberal Studies
- Management
- Sociology
- Theatre
- Writing

A student completes a theme by passing three courses. Each course must be from a different department.

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During the 2004-2005 academic year, serious discussions concerning the future of the theme course requirement were occurring. These discussions included personnel of the College of Interdisciplinary Studies, the unit responsible for theme course program administration; the deans of the other units; and the university administration. These discussions were stimulated by anecdotal evidence that theme courses were not accessible to students. Comments included the following:

- Students were selecting themes based on open seats, not academic interest.
- Graduation was delayed by the lack of available seats in theme courses.
- Instructors were allowing students to enroll in theme course sections beyond capacity.
- Numerous complaints about theme course accessibility were made to the general education director.

Quantitative data supported the anecdotal evidence. Theme course capacity and enrollment by semester are shown in Table I.

TABLE I
THEME COURSE ENROLLMENT BY SEMESTER

Semester	Capacity (Seats)	Enrollment (Students)	Percent of Seats Occupied
Fall 2000	3584	3065	86%
Winter 2001	3936	3557	90%
Fall 2001	4438	3731	84%
Winter 2002	4753	4354	92%
Fall 2002	5473	5013	92%
Winter 2003	5752	5523	96%
Fall 2003	6405	6034	94%
Winter 2004	6722	6477	96%
Fall 2004	7659	7377	96%
Winter 2005	7469	7391	99%

The following can be seen in Table I.

- Academic year theme course capacity increased by 101% from 2000-2001 to 2004-2005.
- Academic year theme course enrollment increased by 123% from 2000-2001 to 2004-2005.
- The percent of seats occupied increased from 88% in academic year 2000-2001 to 98% in academic year 2004-2005.

Thus, while theme course capacity had more than doubled in 4 years, student demand had increased at an even higher rate. In addition, some excess capacity was needed to allow for the following:

- Student freedom of choice in selecting a theme.
- Time conflicts with other courses.
- Location conflicts on the multiple campuses of GVSU.

The majority of theme courses are taught on the Allendale campus and the Grand Rapids campus, 13 miles from Allendale. Some are offered on the Holland campus 20 miles from Allendale and some are offered on the Traverse City campus, about 150 miles from Allendale.

Thus, it was decided to ask faculty of the School of Engineering to forecast the number of theme course seats needed in the 2005-2006 academic year. This forecast could be used to set policies and allocate resources for the effective operation of the theme program.

FORECASTING EQUATIONS FOR THEME SEATS

The forecast of the number of theme seats required for fall semester 2005 and winter semester 2006 was done in multiple steps. First equations that could be used to forecast full-time equivalent (FTE) student enrollment, sophomore through senior, for each semester, fall and winter, were developed using linear regression. The dependent variable (y) was the number of students enrolled and the independent variable (x) is the year (1, 2, 3, 4, 5). Institutional data for the fall semesters of 2000 through 2004 was employed. Results are shown in Table II.

TABLE II
FORECASTING EQUATIONS FOR UNIVERSITY STUDENT ENROLLMENT

Semester	Equation (y =)	Coefficient of Determination (R^2)
Fall Sophomore	209.25*x+2853.4	97.4%
Winter Sophomore	174.51*x+2405.9	86.7%
Fall Junior	181.97*x+2617.7	98.2%
Winter Junior	401.94*ln(x)+2669.7	98.8%
Fall Senior	322.62*x+3243.5	99.3%
Winter Senior	327.68*x+3557.5	99.6%

All of the coefficients of determination were at least 97.4% except for winter semester sophomores. This is expected when fitting five data points using an equation. The high coefficients of determination were evidence that the equations could be used to forecast enrollment for the next year. Since freshman and sophomores take relatively few theme classes, the coefficient of determination of 86.7% for winter semester sophomores was thought to be acceptable.

Freshman enrollment for the fall semester was based on the admission plan for fall 2005. Freshman enrollment for the winter semester was estimated as fall semester enrollment less the historical average loss percent from fall to winter.

In a similar fashion, regression was used to develop equations that could be used in forecasting theme course enrollments by class, freshman through senior, for each semester fall and winter. These equations are shown in Table III. In Table III, y is the number of theme seats required and x is the forecasted student enrollment.

The coefficients of determination for sophomores, juniors, and seniors were all at least 93.2%. For freshman, who take very few theme courses, the coefficients of determination were somewhat low.

An overall coefficient of determination can be computed as the weighted average of the eight coefficients. The weight used was the number of registrations in theme classes in the 2004-2005 academic year. The overall value was 96.2%. This was thought to be acceptable for forecasting purposes.

TABLE III
FORECASTING EQUATIONS FOR THEME COURSE ENROLLMENT

Semester	Equation	Coefficient of Determination (R^2)
Fall Freshman	$-0.001883x^2 + 13.43x + 23307$	88.9%
Winter Freshman	$0.001045x^2 + 5.59x - 6758$	71.8%
Fall Sophomore	$-0.000546x^2 + 4.54x + 23307$	96.1%
Winter Sophomore	$0.000718x^2 + 4.84x - 6757$	93.2%
Fall Junior	$0.000007x^2 + 2.05x - 5053$	98.8%
Winter Junior	$0.002209x^2 + 10.93x - 14332$	94.5%
Fall Senior	$0.001175x^2 - 8.02x + 14393$	99.1%
Winter Senior	$0.000877x^2 - 6.13x + 11522$	98.8%

THE FORECAST AND ITS APPLICATION

Next the accuracy of the forecasting equations was assessed. Forecasts of academic year 2004-2005 theme course enrollment were generated and compared to the actual enrollment. First, a forecast was generated using actual university student enrollment to test the effectiveness of the theme course enrollment equations alone. Results are shown in Table IV.

TABLE IV
FORECAST VS ACTUAL – ACTUAL UNIVERSITY ENROLLMENTS

Semester	Forecast	Actual	Percent Difference
Fall 2004	7380	7377	0.0%
Winter 2005	7469	7481	1.2%

The forecasts are accurate as a very low percent difference is seen. Table V shows the forecasts when forecasted university enrollments are used.

TABLE V
FORECAST VS ACTUAL – FORECASTED UNIVERSITY ENROLLMENTS

Semester	Forecast	Actual	Percent Difference
Fall 2004	7763	7377	5.2%
Winter 2005	7871	7481	6.5%

The university enrollment forecast appears to be slightly high and results in a theme course enrollment forecast of 5.2% to 6.5% higher than actual. This forecast was deemed to be acceptable.

Next, the academic year 2005-2006 forecasts were generated: 9409 in the fall and 9192 in the winter. This is a 23% increased over the actual number of theme seats in the previous academic year.

It was though that this forecast might be slightly (5%) high based on the 2004-2005 validation results. Nevertheless, additional theme seats beyond the forecast were considered for the following reasons:

- Demand wasn't met in academic year 2004-2005 and still needed to be met in academic year 2005-2006.
- Some unused capacity is needed to allow students flexibility in the following:
    - Theme selection
    - Campus selection
    - Scheduling
- Some seats could be made available only when the previously available seats are filled.

Upon review, the university administration decided that providing at least 23% more seats by adding more sections was economically infeasible. Adding more seats to existing classes was pedagogically unsound. After many discussions, it was decided that existing courses could be fast-tracked through the curricular process to quickly add more seats without significantly increasing costs. In addition, students who previously took these courses could count them toward the theme requirement. This reduced the previously unmet student demand and expanded the capacity of the themes.

VALIDATION OF THE SOLUTION

The policy change resulted in a total theme course enrollment in academic year 2005-2006 of 17,218, significantly less (7.4%) than the original forecast of 18,601 seats. For academic year 2006-2007, student enrollment was 93% of theme course capacity. Furthermore, anecdotal evidence is perceived to show far fewer student complaints about theme course availability. In addition, enrollment at 93% of capacity is thought to provide a good balance between the flexibility needed to support student theme and theme course selection and the need to operate the theme course program economically. To increase theme capacity further, the process of adding new courses is ongoing.

SUMMARY

A process for forecasting the enrollment capacity of an upper division, general education requirement, called the themes, at GVSU has been presented. Capacity expansions failed to keep up with the rapid increase in student enrollment. Thus, student access to the theme courses was limited. Forecasting equations for university enrollment and theme course enrollment were developed using regression analysis. The effectiveness of the equations was seen both in high coefficient of determination values, mostly over 95%, and in the accuracy of the forecast academic year 2004-2005 theme course enrollments.

The GVSU administration felt that the forecasted 23% increase in theme course seats for the 2005-2006 academic year was not economic. Thus, policy changes were made that allowed the number of courses in the themes to be increased quickly and that allowed students who had previously passed these courses to use them to meet the theme requirement. These policy changes appear to be effective. For, the 2005-2006 academic year, student enrollment in the theme courses was about 93% of the original forecast. For the 2006-2007 academic year, student enrollments were about 93% of capacity.

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