ACADEMIC PROGRESS OF STUDENTS IN QUANTITATIVE COURSES AT NIGDE UNIVERSITY VOCATIONAL SCHOOL OF SOCIAL SCIENCES: A PREDICTION USING MARKOV MODEL

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Abstract

This study analyzes and predicts the academic progress of vocational school of social sciences students in quantitative courses in order to improve student progress in education. A population of 232 students taking commercial mathematics and statistics courses in 2014/2015 academic year is selected. The academic progress of students are estimated by using final examination scores extracted from OGRIS student otomation system of Nigde University. Academic progress is classified with respect to the mean test score as "greater", "stable" and "lower". Chi-square test is used for statistical analysis and predictions are estimated by one step stochastic Markov chain model. Direction of academic progress is predicted by the product of the initial probability matrix and transition probability matrix. In 2028-2029 academic year, the probabilities of improvement, no change and decline become stable approximately at 28%, 20% and 52%, respectively. The results are discussed and interpreted.

Keywords: *Quantitative Methods, Academic Progress, Transition Probabilities, Markov Model*
Jel Classification Codes: *C120, C2, C530, I21*

NİĞDE ÜNİVERSİTESİ SOSYAL BİLİMLER MESLEK YÜKSEKOKULU ÖĞRENCİLERİNİN SAYISAL DERSLERDEKİ AKADEMİK DURUMUNUN MARKOV MODELİ İLE TAHMİN EDİLMESİ

Özet

Bu çalışma eğitimde akademik durumu geliştirmek için sosyal bilimler meslek yüksekokulu öğrencilerinin sayısal derslerdeki akademik statüsünü analiz eder ve Markov modeli ile tahmin eder. 2014/2015 öğretim yılında ticari matematik ve istatistik derslerini alan 232 öğrencinin hepsi seçilmiştir. Niğde Üniversitesi OGRIS otomasyon sisteminden elde edilen final sınavı notları kullanılarak öğrencilerin akademik statüsü tahmin edilmiştir. Akademik statü daha yüksek, durağan ve daha düşük olarak sınav ortalamalarına göre sınıflandırılmıştır. İstatistik analizi için ki kare testi ve tahminleme için de Markov zinciri modeli kullanılmıştır. Akademik statünün yönü başlangıç olasılık matrisinin geçiş matrisi ile çarpımı sonucunda tahmin edilmiştir. 2028-2029 akademik yılında gelişme, durağan ve düşüş olasılıkları yaklaşık olarak sırasyla 28%, 20% and 52% tahmin edilmiştir. Sonuçlar tartışılmış ve yorumlanmıştır.

Anahtar Kelimeler: *Sayısal Yöntemler, Akademik Performans, Geçiş Olasılıkları Matrisi, Markov Analizi*
Jel Kodları: *C120, C2, C530, I2*

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INTRODUCTION

Vocational schools are two year educational institutions with specific professions such as business management, banking and insurance, and accounting and tax practices. Vocational schools in Turkey do not require a preliminary test or a university entrance test. A large number of students are enrolled to vocational schools.

Quantitative courses at vocational schools of social sciences are known to be most difficult courses by students. Unsuccessful students considered that difficult lectures, inadequate mathematics background and too many demands on time were more influential factors for failure (Anthony, 2000:3-14).

Direction of student progress determines timely graduation from two year vocational school of social sciences where students need to take 120 credits in four academic terms. Vocational Schools enroll students mostly from vocational high schools with no preliminary examinations or with low scores in university entrance exam. It is widely reported that the main determinant of success at university is the score on university entrance exams (Birch&Miller, 2007). Weak background in quantitative courses and inconsistency of student levels are main obstacles to a quality learning environment and to a vocational school's success. Therefore prediction of student progress has a great importance in improving student progress in higher education.

In 2015-2016 academic year, 8845 students are enrolled to six vocational schools of Nigde University, which is 36% of total number of students. 2871 of 8845 are at vocational school of social sciences, which is 32,5% of students at all vocational schools and 12% of total number of students at NU (http://www.nigde.edu.tr/oidb/sayfa/ogrenci-sayilari date retrieved: 28.02.2016).

This paper will analyze students performance in two quantitative courses by using final examination grades from Nigde University Vocational School of Social Sciences and will construct a student progress model by Markov chain.

I. LITERATURE

Ma & Kishor (1997) investigated the relationship between the attitudes toward mathematics and mathematics achievement that consisted of 113 original studies showed a positive relationship between mathematics attitudes and mathematics performance, with a longitudinal model suggesting that mathematics attitudes actually constitute a causal factor in mathematics achievement.

Alrwais (2000) found that best predictor of mathematics achievement was the students' attitude toward mathematics learning.

Abu-Hilal (2000) found that students' perceptions of the importance of mathematics exerted a significant effect on achievement.

Henden and Tunç (2005) indicated that enrolling to vocational schools without exam after high school and continuing education did not give students a feeling like they attended a university.

Wainwright (2006) analyzed enrollment data from five consecutive years from a state university regional campus, and constructed an enrollment retention model using a Markov process. The model was used to analyze enrollment retention rates for commonly overlooked segments of the student population, as well as the retention rates for specific degree programs, rather than just the retention rates for aggregate incoming freshmen.

Türeli and Çağlar (2007) found that students enrolling to Isparta Vocational School with a university entrance test score were more successful than those enrolling without an exam score.

Birch and Miller (2007) asked 130 male and 112 female undergraduates to rate their ability, amount of preparation, task difficulty, and their initial confidence (expectation) before they began an important examination. Subsequently Ss attributed causality for the examination outcome by rating the importance of factors involving ability, preparation, task difficulty, and luck as causes. Results show that amount of preparation (knowledge) contributed most to initial confidence ratings, followed by amount of ability.

Dursun (2008) found that students enrolling to Vocational School with a university entrance test score were more successful in math clasees than those enrolling without an exam score.

Alawadhi and Konsowa (2010) predicted the probability of graduation with respect to colleges and academic levels of students. Markov analysis was used to investigate the flow process of students in Kuwait University. Graduation, dropping out, and transferring were classified as absorbing states. Student life time was also estimated.

Ilgan (2013) showed that the total study time was the most significant variable that explained academic achievement of college students in science research methods course.

Adeleke et. al (2014) studied the pattern of students' enrolment and their academic performance in the Department of Mathematical Sciences (Mathematics Option) Ekiti State University, Ado – Ekiti, Nigeria. A transition matrix was developed for ten consecutive academic sessions. The probabilities of absorption (Graduating and Withdrawal) were obtained. Also fundamental matrix was obtained to determine the expected length of students' stay before graduating. Prediction was made on the enrolment and academic performance of students.

Farg and Khalil (2015) predicted the trend of the student academic status using a population of 98 students in faculty of science and humanities, at Shaqraa University, KSA. A Markov chain and chi-square were used for data analysis, the first was used to determine stability of Markov matrix, and the second was used to test statistical significance, and found that the actual frequency distribution of transitions was significantly different from the theoretical one. The academic level of the student was stable in the fifth semester, and the probability for improvement, decline and stability in the academic level were 64%, 27 % and 9% respectively.

II. METHODOLOGY: MARKOV MODEL

Markov chain is a stochastic process which is described by a transition matrix of transition probabilities from one state into another state.

A discrete time process $\{X_n, n = 0,1,2,...\}$ with discrete state space $X_n \in \{0,1,2,...\}$ is a Markov chain if it has the Markov property: $P(X_{n+1}=j \mid X_n=i,\ X_{n-1}=i_{n-1},\ ...,X_0=i_0) =$

$P(X_{n+1}=j|X_n=i) = p(i,j)$ where $p(i,j)$ depends only on the states i,j, and not on the time n or the previous states" (dept.stat.lsa.umich.edu/~ionides/620/notes/markov _chains.pdf date retreived:11.12.2015). The numbers $p(i,j)$ are called the transition probabilities of the chain (galton.uchicago.edu/~lalley/Courses/312/MarkovChains.pdf date retrieved: 11.12.2015).

In a first order Markov chain, the state at any time instant depends only on the state immediately preceding it (Öztürk, 2014:735). One step probability is $p_{ij}=P(X_1=j \mid X_0=i)$ and and m step probability is $p^m_{ij}=P(X_m=j \mid X_0=i)$ (Lipták, 2011: 141–142).

II.I. Construction of Transition Probabilities

Transition probability matrices are estimated for 2014-2015 academic year for two final examination grades. After sample mean of commercial mathematics examination for each program is found, each commercial mathematics exam score is categorized as one of the three states with respect to commercial mathematics mean exam score. If a commercial mathematics exam score is greater than the mean, it is categorized as "greater" for greater than mean; if it is the same as mean, it is categorized as "stable" and if it is less than the mean, it is categorized as "lower" for lower than mean. Statistics final examination scores are categorized with respect to commercial mathematics final examination score. Greater scores are categorized as "G", same scores are categorized as "S" and lower scores are categorized as "L". Transition matrix of frequencies of academic states is constructed with respect to the three states.

The estimator of the transition probabilities is the relative frequency of the actual transitions from phase i to phase j, i.e. the observed transitions have to be divided by the sum of the transitions to all other phases (Lipták, 2011: 141).

In this paper, $P_{ij} = n_{ij} / \sum_j n_{ij}$ where i, j = G, S, L and n_{ij} is the number of observed transitions from i to j and $\sum_j n_{ij}$ is the sum of observed transitions from i to j.

Frequency distribution of the realization rate intervals must be mutually exclusive (nonoverlapping) and class width must be equal for each interval (Bluman, 2014: 45-46).

Transition probabilities from X_i to X_j, $i, j = 0,1,2,\ldots,n$, can be constructed as the following matrix (Taha, 2000:726)

$$P_{ij} = \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ P_{n1} & P_{n2} & \cdots & P_{nn} \end{bmatrix}$$

Since p_{ij} are constant and independent of time (time homogeneous), matrix $P_{ij} = P$ is called a stochastic matrix. P_{ij} probabilities must satisfy the following conditions: (Öztürk, 2014:735)

P is a square matrix $\quad P_{ij} \geq 0 \quad \forall i, j = 1,2,\ldots, n \qquad \sum_{j=1}^{n} P_{ij} = 1 \quad \forall i = 1,2,3,\ldots, n$

II.II. Prediction

Given that data at time n is in state X_0 and that the data will be in one of states $X_n \in \{0,1,2,\ldots\}$ at time n+1, then the data at time n+2 can be predicted. Given initial probability

$P(X_0 = i) = p_i$ for every i, the required probability is matrix multiplication $p_i \sum_k P_{ik} P_{kj}$.
Equivalently, next year's probability distribution matrix can be predicted by

$$Q_{n+1} = Q_n P \qquad n = 0,1,2,3,\ldots \qquad (1)$$

Initial probability matrices for four Markov models are $1xj$ row matrices. Stationary prediction matrices Q_{n+1} have a limiting matrix Q, which can be written as $\lim_{n\to\infty} Q_n = Q$.

II.III. Statistical Significance of the Models

Variations between observed and expected frequencies can be tested by constructing a contingency table of frequency distribution of transitions between the states at 0,05 significance level with a degree of freedom. To validate Markov model the value of the χ^2 statistic is computed based on the null hypothesis, H_0: No significant difference. At 0,05 level of significance and with the degrees of freedom, the χ^2 critical value and χ^2 test value are estimated. The null hypothesis is not rejected whenever χ^2 test value is less than the critical value. Test values are calculated by

$$\chi^2 = \sum_i \frac{(O_i - E_i)^2}{E_i}$$

where i is the number of categories, and O_i and E_i are the actual and estimated values, respectively.

III. ASSESMENT AND EVALUATION OF COMMERCIAL MATHEMATICS AND STATISTICS TESTS

One midterm (40%) and one final examination (60%) were given to students for assesment in 2014/2015 academic year. There was ten questions on each examination. Each question was worth ten points. Each examination was evaluated out of 100 points. Examinations were evaluated according to relative evaluation guidelines of Nigde University (http://nigde.edu.tr/oidb/sayfa/yonergeler date retreived: 27.02.2016)

III.I. Frequency of Transitions of Student Status

Student status (states) are classified as G,S and L for the two tests. Frequency of transitions between the states are given in table 1.

Table 1. Transition Frequency Matrix

Transitions		Statistics State			Total
		G	S	L	
Commercial Math State	G	17	3	103	123
	S	2	0	8	10
	L	39	36	24	99
Total		58	39	135	232

Source: Own collaboration

Table 1 shows that 114 students taking statistics have lower grades than their commercial mathematics grades and 77 students taking statistics have higher grades than their commercial mathematics grades. Of students who scores over the mean score in commercial mathematics only 17 receives a higher grade in Statistics, which is 7% of the total population in the table. This is a very low rate for student success.

III.II. Transition Probability Matrix

Transition probability matrix is constructed from Table 1 by dividing each transition frequency by its row sum.

$$P = \begin{bmatrix} P_{GG} & P_{GS} & P_{GL} \\ P_{SG} & P_{SS} & P_{SL} \\ P_{LG} & P_{LS} & P_{LL} \end{bmatrix} = \begin{bmatrix} 17/123 & 3/123 & 103/123 \\ 2/10 & 0 & 8/10 \\ 39/99 & 36/99 & 24/99 \end{bmatrix}$$

III.III. Statistical Significance of The Model

Variations between observed and expected frequencies can be tested by constructing a contingency table of frequency distribution of transitions between the states at 0,05 significance level with 4 df. Since chi square test value 87,94 is greater than critical value 9,488, H_0 is rejected. This shows that there is significant difference between actual and expected frequencies. The values in paranthesis in table 4 are expected frequencies which are found from (row sum X column sum)/total. Table 4 shows that transitions in higher state are declining and those in lower state are improving.

Table 4. Contingency Table of Observed and Expected Frequencies

	G	S	L	Total
G	17(30,7)	3(20,7)	103(71,6)	123
S	2(2,5)	0(1,7)	8(5,8)	10
L	39(24,8)	36(16,6)	24(57,6)	99
Total	58	39	135	232

Source: Own Collaboration

IV. STATIONARITY

Predictions are estimated in Excel by formula (1). According to the model, probabilities become stationary in 2028-2029 academic year.

VI.I. Construction of Initial Probability Matrix

Initial probability matrix Q_0 can be constructed by dividing row sum by the total number of frequencies in Table 4. 123/232, 10/232 and 99/232 respectively gives the initial probability matrix approximately $Q_0 = [0{,}53 \quad 0{,}04 \quad 0{,}43]$.

VI.II. Stationarity of Student Progress Predictions

To predict student progress in 2015-2016 academic year, the initial matrix constructed from 2014-2015 academic term is multiplied by transition probability matrix, to predict student progress in 2016-2017 academic year, 2015-2016 predictor matrix is multiplied by the transition probability matrix and continuing these matrix multiplications results in a stable matrix in 2028-2029 academic year. Table 5 shows that predictions become stationary in 2028-2029 academic year.

Tablo 5. Student Progress Prediction

State / Year	G	S	L
2015-	0,2500	0,1681	0,5819
2016-	0,2974	0,2177	0,4849
2017-	0,2757	0,1836	0,5407
2018-	0,2878	0,2034	0,5088
2019-	0,2809	0,1920	0,5271
2020-	0,2849	0,1985	0,5166
2021-	0,2826	0,1948	0,5226
2022-	0,2839	0,1969	0,5192
2023-	0,2831	0,1957	0,5211
2024-	0,2836	0,1964	0,5200
2025-	0,2833	0,1960	0,5207
2026-	0,2835	0,1962	0,5203
2027-	0,2834	0,1961	0,5205
2028-	0,2834	0,1962	0,5204

Source: Own collaboration * stationarity year

Limiting matrix is Q = [0,2834 0,1962 0,5204]. This stationay matrix shows that in 2028-2029 academic year the probability of improvement in academic progress is approximately 28%, that of no change in academic progress is approximately 20% and that of decline in student academic progress is approximately 52%.

V. TECHNOLOGY

Formula (1) is used in Excel. Transition probability matrix is input in cells A1:C3 and initial probability matrix Q_0 is input in cells B8:D8. Prediction of progress for 2015-2016 academic year was estimated in cells B9:D9 by matrix multiplication in formula (1):

=B8*A1+C8*A2+D8*A3 =B8*B1+C8*B2+D8*B3
=B8*C1+C8*C2+D8*C3

Cells B9:D9 were selected and dragged down from lower right hand side of cell D9 to predict academic progress for 2016-2017 and for future academic years.

Expected frequencies of transitions and χ^2 test value is calculated by TI36XPro scientific calculator.

FINDINGS, RESULTS AND DISCUSSIONS

According to transition matrices, transitions of status are declining in high state and improving in low state. In 2028-2029 academic year, 52% of students would get a lower grade in statistics course than commercial mathematics grade. This shows that commercial mathematics does not support students to be successful in statistics course. Therefore, a prerequisite mathematics course should be offered for statistics course. To improve student progress in statistics, a basic mathematics course can be offered to students in Business Management, and Banking and Insurance Programs at Nigde University Vocational School of Social Sciences. Independent of commercial mathematics course, a 2+0 credit basic mathematics course can be added to mandatory course offerings list and the 3+0 credit commercial mathematics course can be decreased to a 2+0 credit course in both programs. A course objectives list for the two courses is suggested in the appendix.

According to the model of student success, the probabilities of three states will be stable in 2028-2029 academic year. Probability that a student does relatively better in statistics is improving from 25% in 2015-2016 to a stable 28.34% in 2028-2029. Probability of a student to have same grade in statistics is improving from 16.81% in 2015-2016 to a stable 19.62% in 2028-2029. Probability of getting a lower grade in statistics is decreasing from 58.19% to a stable 52.09% in 2028-2029. Even though probability of getting a lower grade in statistics is decreasing to 52%, it is a high probability for failure.

The factors to academic failure in quantitative courses are based on attidudes toward quantitative courses, confidence, background and study time. Henden and Tunç (2005) indicated that enrolling to vocational schools without exam after high school and continuing education did not give students a feeling like they attended a university. Ma & Kishor (1997) suggested that mathematics attitudes actually constitute a causal factor in mathematics achievement. Alrwais (2000) found that best predictor of mathematics achievement was the students' attitude toward mathematics learning. Abu-Hilal (2000) found that students' perceptions of the importance of mathematics exerted a significant effect on achievement. Birch and Miller (2007) showed that amount of preparation (knowledge) contributed most to initial confidence ratings, followed by amount of ability. Ilgan (2013) showed that the total study time was the most significant variable that explained academic achievement of college students in science research methods course. Türeli and Çağlar (2007) found that students enrolling to Isparta Vocational School with a university entrance test score were more successful than those enrolling without an exam score. Dursun (2008) found that students enrolling to Vocational School with a university entrance test score were more successful in math clasees than those enrolling without an exam score.

This study can be used to predict student progress in other courses. School management can take the advantages of this study in planning improvement of student progress.

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http://nigde.edu.tr/oidb/sayfa/yonergeler 27.02.2016

http://www.nigde.edu.tr/oidb/sayfa/ogrenci-sayilari 28.02.2016

APPENDIX

Basic mathematics for vocational school of social sciences can be taught 2+0 credits per week in the first term of the first year.

Course Objectives
1. To add, subtract, multiply and divide numbers 2. To apply the order of operations with integers and rational numbers 3. To make conversions between percent-decimal, percent-fraction and decimal-fraction 4. To solve linear equations, proportions and linear inequalities 5. To plot points and graph equations 6. To find range, midpoint, mean, median

Commercial mathematics should be taught 2+0 credits per week in the second term of the first year. Course objectives under course description in Bologna process should be as given in Table A1.

Course Objectives
1. To understand the basic concepts of commercial mathematics 2. To solve percent, profit-loss, mixture and alloy problems 3. To solve discount and mark up problems 4. To solve cost, selling price and profit problems 5. To learn about exchanging promissory notes 6. To calculate simple interest, future value, present value, time and rate 7. To calculate compound interest, future value, present value