Bayesian Model Selection in Learning Outcome

Nguyen Thi Ngan, Bui Huy Khoi
{buihuykhoi@iuh.edu.vn}

Industrial University of Ho Chi Minh City, Vietnam

Abstract. The learning outcome of each student depends a lot on factors, learning spirit, level of interest in learning, training, and taking part in activities to create the best environment for developing skills, improving their academic achievement, and the influence of the learning environment, work, teamwork, etc. The paper uses Bayesian Model Selection in Learning Outcome: Case Study of Industrial University of Ho Chi Minh City (IUH), Vietnam. It is used to discover a research model comprising 06 factors Facilities (FAC), Lecturer (LEC), University (UNI), Learning Motivation (MOT), Learning Method (LM), and Friend (FR). We collected a sample of 98 responses in the analysis. The results show that Lecturer (LEC), University (UNI), and Friend (FR) influence Learning outcome (LO). From the research results, the author has given some implications to help managers improve learning outcomes. Previous studies revealed that using linear regression. This study uses the optimal choice of Bayesian Model Selection.

Keywords: buying decision; products; Bayesian

1 Introduction

The learning outcome of each student depends a lot on factors, learning spirit, level of interest in learning, training, and taking part in activities to create the best environment for developing skills, improving their academic achievement, and the influence of the learning environment, work, teamwork, etc. [1]. The paper aims to understand and evaluate the influence on the learning outcomes of students from IUH. This study understands and evaluates the influence on the learning outcomes of students at IUH. Through the research results, analyze and process the data obtained during the research process to give lecturers and students a more intuitive view of the factors affecting the learning outcomes and factors affecting learning outcomes. From there, take measures to improve student outcomes to solve the urgent problem of finding out the factors that affect the students' learning outcomes to affect the learning results students and propose some measures to help improve the learning outcomes of students at IUH during their study and participation in activities to help students to improve the quality of learning and achieve better results. Helping the university to have orientations and policies in management and improve student quality. Through the research results, analyze and process the data got during the research process to give lecturers and students a more intuitive view of the factors affecting the learning outcomes. From there, take measures to improve student outcomes. The paper uses Bayesian Model Selection for Learning Outcome: Case Study of IUH to solve the urgent problem of finding out the factors that affect the students' learning outcomes and propose some measures to help improve the learning outcomes of students at IUH during their study and participation in activities to help students improve the quality of learning and

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achieve better results and the university to have orientations and policies in management and improve student quality.

2 Literature Review

Learning outcome (LO)

Learning outcome (LO) is a term that researchers have given many definitions [2]. It is defined as the overall assessment of the students themselves about the knowledge and skills they have gained in studying subjects at university [3]. According to Winarso [4], intermediate performance is evidence of students' success in terms of knowledge, skills, and attitudes, which have been outlined in educational goals.

Facilities (FAC)

University facilities and technology are systems of various physical and technical means used to serve the comprehensive education and training of students. Facilities include lecture halls, laboratories, computer rooms, and equipment [5]. Learning materials include books, journals, ebooks, open materials, specialized documents, information, and communication technology that meet training implementation and learning environment. The study of Roberts [6] has also shown that facilities are one factor affecting the learning outcomes of students.
Hypothesis (H1): Facilities have a positive impact on student learning outcomes.

University (UNI)

The impression of a brand - that of the product or the organization - reflects the customer's perception of that brand [7, 8]. As a business, a university is an organization that educates and trains human resources for the country. A university with an excellent reputation, good training quality, an increasingly modern learning environment, etc. will make a good impression on students and help students get high academic achievements. A training program is a content, organizational structure, functions, tasks, and academic-related activities of a training unit being deployed to train a discipline in a certain level of study. Moely and Ilustre [9] showed that the characteristics of the university have an impact on students' learning outcomes. Therefore, hypothesis H2 is put forward:
Hypothesis (H2): The University has a positive impact on student learning outcomes.

Lecturer (LEC)

Lecturers play an important role in student learning [10]. They are guides, directions, and suggestions for learning methods so that students can absorb knowledge and learn more easily. Therefore, the capacity of highly qualified lecturers, the ability to communicate, and the method of subject organization will affect the learning process of each student. Research by Lim and Morris [11] also shows that the teacher's factor will affect the learning outcomes of students.
Hypothesis (H3): Lecturer has a positive impact on student learning outcomes.

Learning Motivation (MOT)

Students learning motivation is the desire to get something [12], be it a university scholarship or to prove themselves, the motivation, and the goal that each student aspires to. In the study of Ulyani and Qohar [13] on factors affecting learning outcomes, learning motivation is one of the influential factors.

Hypothesis H4: Motivation has a positive impact on student learning outcomes.

Learning Method (LM)

Each student needs to make a study plan for themselves [14], take time to study on their own, and then organize interactive activities, and exchange with friends, and teachers to deepen their understanding of the problem and knowledge in the best way. In this study, the learning methods mentioned are self-study and teamwork-based learning. According to the research of Prasetya and Harjanto [15], the factor of learning method influences the learning outcomes of students.

Hypothesis (H5): Learning methods have a positive impact on student learning outcomes.

Friend (FR)

The more peers a student has to motivate their learning and who behave positively, the more it can affect improving learning outcomes [16]. There is a saying "Learning from a teacher is not good at studying friends". Friends are people of the same age and it is easier to exchange access to knowledge than with lecturers. Friends will influence each other through learning each other's knowledge and skills, sharing and learning from each other. According to a study by Hutanto [16], the friend factor has a positive effect on students' learning outcomes.

Hypothesis (H6): Friends have a positive influence on student learning outcomes.

3 Method

Sample

According to Tabachnick and Fidell [17] for the best regression analysis, it is necessary to ensure the sample size as follows: $N \geq 8m + 50$. The results of gender statistics show that out of 98 survey subjects, there are 34 respondents of the male gender, accounting for 34%. Gender Female has 64 respondents, accounting for 65.3%. This shows that there is a difference in the ratio of males and females in this survey. According to data, the number of second-year students responding to the survey accounted for the highest rate, with 68.4%, and the lowest rate of fourth-year students, accounting for only 3.1%. It can be seen that second-year students are easier to survey and receive more support. This is the same age group as the survey authors. Table 1 describes the statistics of sample characteristics.

Table 1. Statistics of Sample.

Characteristics		Amount	Percent (%)
Sex and School Year	Male	34	34.7
	Female	64	65.3
	First	15	15.3
	Second	67	68.4
	Third	13	13.3
	Fourth	3	3.1
Faculty	Business Administration	44	44.9
	Auditing and Accounting	6	6.1
	Tourism Business	9	9.2
	Mechanical Engineering	1	1.0
	Foreign Language	5	5.1
	Fashion Garment	2	2.0
	IT	3	3.1

	Food	6	6.1
	Construct	6	6.1
	Banking and Finance	8	8.2
	Other	8	8.2

From the statistical results, it shows that the business administration sector accounts for the highest number and percentage of the industries because the research team mainly belongs to this industry another reason is according to secondary data collected from the business administration sector has the largest number of scholarship winners, so it is necessary to find out which factors positively affect the learning outcomes of students of the Faculty of Business Administration. Besides, the two groups of Mechanical Engineering and Fashion Garments have the smallest number and percentage (only 1 and 2%).

Bayesian Model Selection

The best model for R software was chosen to use BIC (Bayesian Information Criteria). In the theoretical environment, BIC has been used to choose models. BIC can be used as a regression model to estimate one or more dependent variables from one or more independent variables [18]. The BIC is an important and useful metric for determining a full and straightforward model. A model with a lower BIC is chosen based on the BIC information standard. When the minimal BIC value is reached, the best model will end [18-20].

4 Results

4.1 Mean

Table 2. Mean

Factor	Item	Mean
LO	Last semester's results	3.02
LEC	Lecturers help you absorb knowledge easily and achieve good learning results	3.13
MOT	University supports scholarships to make you more interested in improving your academic results.	3.48
FAC	Modern facilities will help students learn excitedly and achieve high learning results	4.37
UNI	University training helps you learn better The learning environment makes your study results better	3.46
LM	Students who spend more time on self-study will achieve better learning results Teamwork will achieve high academic results	4.1
FR	Students learn knowledge and skills from friends to help them achieve good academic results Students want to do teamwork	3.9

Factors and items are in table 2. The mean of items is from 3.02 to 4.37, being good with research data in table 2. Facilities (4.37) are appreciated the best.

Bayesian Model Selection

Every stage of the search for the best model is detailed in the R report. BIC selects the best 5 models in table 3.

Table 3. Bayesian Model Selection

LO	Probability (%)	SD	model 1	model 2	model 3	model 4	model 5
Intercept	100.0	1.21818	-0.1680	1.0185	0.8566	2.1220	-0.9408
LEC	95.3	0.11333	0.3104	0.2676	0.3305	0.2868	0.2984
MOT	7.6	0.02722	.	.	.	.	.
FAC	20.7	0.08989	.	.	.	.	0.1763
UNI	55.2	0.20084	0.3254	0.3364	.	.	0.3243
LM	13.7	0.08037	.	.	.	.	.
FR	51.1	0.17115	0.2775	.	0.2872	.	0.2889

There are six independent and one dependent variable. Lecturer (LEC) influences Learning outcome (LO) with a Probability is 95.3% and University (UNI) and Friend (FR) influence Learning outcome (LO) with an average probability is 55.2% and 51.1%. Facilities (FAC), Learning Method (LM), and Motivation (MOT) influence Learning outcome (LO) with low probability is 20.7%, 13.7%, and 7.6%.

Model Evaluation

Table 4. Model Test

Model	nVar	R^2	BIC	post prob
model 1	3	0.173	-4.8437	0.156
model 2	2	0.133	-4.7767	0.151
model 3	2	0.131	-4.6220	0.140
model 4	1	0.088	-4.4595	0.129
model 5	4	0.192	-2.5834	0.050
BIC = -2 * LL + log(N) * k				

According to the results from table 4, BIC shows model 1 is the optimal selection because BIC (-4.8437) is minimum. Lecturer (LEC), University (UNI), and Friend (FR) impact learning outcome (LO) is 17.3% in table 4. BIC finds model 1 is the optimal choice and three variables have a probability of 15.6%. The regression equation below is statistically significant, according to the analyses above.

$$\mathbf{LO = -0.1680 + 0.3104LEC + 0.3254UNI + 0.2775FR}$$

Discussion

The analysis results of the Bayesian Model Selection have identified the factors affecting the students' Learning outcome (LO) at the University of Industry in Ho Chi Minh City, which are University (UNI), Lecturer (LEC), and Friend (FR). Combining the results from the model and the current learning situation of students at the University of Industry, as well as based on the beta coefficient of each independent variable, the group makes the following recommendations:

University (0.3254): First, it is necessary to adjust training programs accordingly by adding more specialized knowledge for students, and enhancing practical and practical activities associated with the needs of society to create a learning environment for students. Second, the training program is always updated and renewed so that students can study effectively and grasp the trend. Third, it always creates a modern and friendly learning environment for students and creates excitement for students.

Lecturer (0.3104): They need to provide students with full official learning resources, as well as subject-related resources. This is a condition for students to easily absorb all the knowledge of the subject, besides listening in class, students can study and learn more at home. They need to pay more attention to their students and create conditions for students to understand the content of the course by doing more practical exercises, group exercises, and specific and vivid examples to avoid situations. Students only focus on grades, not on knowledge and practical application.

Friend (0.2775): Students should build many good relationships in school and society. This will help students in study and work. When they do not understand the lesson, they will be helped by their friends, learning knowledge from their friends that they do not have. Students need to be proactive, flexible, and sociable with people around them to learn from each other, and support and help each other in learning and applying knowledge in society. Having friends, students will be compensated and learn from each other knowledge and skills in life through which they can cultivate themselves and develop more, such as learning from each other how to think critically, and communication skills.

5 Conclusions

This study was conducted to determine the factors that affect the learning outcomes of students, the case study at IUH by the optimal choice of Bayesian Model Selection. Students of all majors have quite good academic performance, with about 84.6% of students achieving good or higher performance. Second- and third-year students do better because they have more appropriate learning methods and are better adapted to credit-based learning. There are no students with poor academic performance. University factors such as Lecturer (LEC), University (UNI), and Friend (FR) influence the social performance of students of public universities. And the scholarship factor has an unknown influence on the financial performance of students at IUH.

Limitations

We found some limitations that we have not exploited in the research topic, which are that they could not calculate the student's financial performance, have not exploited as well as mentioned the influencing students' social relations, specifically online learning (because of the Covid epidemic, sometimes students have to study online), the problem of working part-time, ...

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