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Analysis of Factors Affecting Students' Grade Point Average (GPA) in Cirebon University Using Multiple Discriminant Analysis

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Abstract: This research explores the factors that influence student academic achievement within the context of public and private universities located in Cirebon, Indonesia. The study employs discriminant analysis as its primary analytical method, utilizing primary data collected through questionnaires distributed to students across these institutions. The central aim is to identify and analyze the key determinants that significantly affect students' academic performance.The findings of the research highlight the significant impact of intelligence quotient (IQ) and study hours on student achievement. Furthermore, the analysis reveals that gender and university type (public or private) also play a role in differentiating levels of student achievement. These results contribute to a more nuanced understanding of the variables influencing academic success in the region. By employing discriminant analysis, the study effectively classifies students into distinct academic performance groups, specifically those with a GPA below 3.5 and those with a GPA of 3.5 or higher. This approach allows for the identification of factors that reliably distinguish between these groups. The outcomes of this research are intended to provide valuable insights for universities and educational stakeholders, enabling them to develop targeted strategies and support mechanisms to foster improved student outcomes and enhance the overall quality of higher education.

Keywords: discriminant analysis; iq; student achievement index

INTRODUCTION

The accelerating pace of globalization makes the development of human resources (HR) crucial for global competitiveness. Intelligent and high-quality HR is the primary driver of national progress and civilization. Education holds the key to significant change, as improved educational quality directly correlates with the quality of a society. This is evident in nations with high educational attainment producing highly skilled graduates. Indonesia's legal framework for education, outlined in Law No. 20 of 2003 on the National Education System *(Sisdiknas)*, aims to foster a well-rounded citizenry with strong character, intelligence, capability, independence, and responsibility. Education is defined as a conscious and planned effort to develop learners' potential democratically and equitably across formal, non-formal, and informal channels. This law also governs curriculum, educators, rights, obligations, funding, and management, all designed to establish a high-quality national education system.

Ultimately, enhancing educational quality is essential for cultivating superior HR capable of competing both nationally and globally, mirroring the success of countries like South Korea, Singapore, Germany, and Finland, which thrive through strategic investment in education, research, and a focus on relevant skill development (OECD, 2023).

Higher education plays a vital role in producing graduates equipped with not just theoretical knowledge, but also 21st-century skills such as critical thinking, creativity, collaboration, and communication, all essential for navigating global challenges (World Economic Forum, 2020). In Indonesia, challenges in higher education include improving on-time graduation rates, ensuring curriculum relevance to industry demands, and generally enhancing learning quality. Efforts to boost national educational quality involve updating the existing system and improving factors that contribute to student academic success. This applies to all institutions, especially universities, which are responsible for producing top-tier graduates. Highly qualified and professional educators are paramount in this endeavor.

Indonesian universities must offer undergraduate programs that cultivate competent HR capable of thriving in various professions and competing globally. The escalating competition in Indonesia mandates that universities enhance their quality and systems to attract and retain highly competent students. A significant concern, for instance, is the issue of students graduating late or not at all, which can hinder the university's development and reputation. A student's Grade Point Average (GPA) is a key indicator of their ability to successfully follow university lectures, reflecting their academic progress and understanding.

A student's GPA directly reflects their academic quality and competence. A high GPA can lead to reduced study time, open doors to scholarships for financial support, and significantly increase their potential for easy acceptance into the workforce due to their proven abilities. This research therefore focuses on identifying and analyzing the factors that significantly differentiate groups of students based on their GPA: those below 3.5 and those at 3.5 or above. Understanding these factors is crucial because GPA is widely considered a primary indicator of academic success and graduate competence. Identifying these influencing factors is not only vital for students to improve their academic performance but also for universities to design more effective support and intervention strategies, ultimately enhancing the overall quality of graduates and, by extension, national human resources.

Previous studies have identified various factors influencing student GPA. (Hussain et al., 2011) found a positive correlation between motivation, study habits, and attendance with GPA. A meta-analysis by (Credé & Kuncel's, 2008) highlighted cognitive ability and conscientiousness as strong predictors of academic performance, while (Richardson et al, 2012) noted the role of social support and academic anxiety. In Indonesia, (Rahayu & Wirawan, 2020) demonstrated a positive influence of the learning environment and lecturer support on GPA. However, most prior research tends to use correlation or linear regression to analyze GPA factors. Studies applying Multiple Discriminant Analysis to classify students into high and low GPA groups based on a combination of factors remain limited, particularly in Indonesia. This study aims to bridge this gap by utilizing multiple discriminant analysis to identify significant differentiating variables between GPA < 3.5 and GPA ≥ 3.5 groups, considering factors such as study hours, IQ, age, semester, university, and gender. The expected results will provide in-depth insights into the combination of factors predictive of academic success and offer specific practical implications for educational institutions.

METHODS

This study used a cross-sectional quantitative survey to examine the relationship between age, gender, semester, university, study hours and GPA. The aim is to categorize which factors are significant in influencing a person's IQ.

Participants

The participants of this study consisted of 244 active students from various private and public universities located in Cirebon City and Regency. Data was collected through a Google Form that was distributed online. The sampling method used was convenience sampling and voluntary response sampling, as participation was optional and based on the willingness of students who accessed the survey link. All participants met the criteria of being active university students in the Cirebon area. Participation was voluntary, and consent was obtained from each student who completed the form.

Procedure

Data was collected over a two-week period. Google form-based questionnaires were distributed via online or social media. The average time taken to complete the questionnaire was approximately 15 minutes. Participants were instructed on how to answer the questions properly and were assured of the confidentiality of their responses, and were guaranteed confidentiality.

Data Analysis

Data collected from 244 students from various private and public universities in Cirebon City were analyzed using IBM SPSS Statistics 27. Descriptive statistics and preliminary correlation analysis were conducted to obtain an overview of the data and the relationships between variables. To test the research hypothesis and predict group membership based on a combination of predictor variables, discriminant analysis was applied.

Ethical Considerations

Ethical approval was obtained from the institution's ethics committee. Participation was voluntary, and participants were allowed to withdraw at any time. Data were anonymized and used only for research purposes.

RESULT AND DISCUSSION

Discriminant Analysis is a multivariate dependence statistical method in which the method is included in the dependence method with dependent and independent variables. Thus, the results of some variables depend on information from the independent variables. Discriminant analysis is also used in circumstances where we need to create a model to predict group membership based on the data considered, particularly quality, mentality, and segment information.

In discriminant analysis, there are several conditions that must be adjusted, namely:

a. The dependent variable must have a non-metric measurement scale (nominal or ordinal). Because this character helps separate objects into two or more groups, this is very basic.
b. The independent variable must have a metric scale (interval or ratio).

The stages in discriminant analysis can be divided into several processes as follows:

1) Categorize each variable into dependent variables and independent variables.
2) Determine how to create a discriminant function based on two important steps including:

- All variables are entered together and then proceed with the discrimination process (Simultaneous Estimation).
- Each variable is entered individually into the discriminant model. Usually, there are variables that play a role in this stage, although it is still possible to eliminate at least one independent variable from the model (Step-wise Estimation).

3) Based on the discriminant equation, the next step is to evaluate the significance level using Wilk's Lambda value, F test, and so on.
4) Test the classification accuracy using Casewise Diagnostic.
5) Run the interpretation of the discriminant equation formed.
6) Run the validity test of the discriminant equation.

The following are the results of discriminant analysis using a computer program, among others:

Table 1. Analysis Case Processing Summary

Unweighted Cases		**N**	**Percent**
Valid		244	100.0
Excluded	Missing or out-of-range group codes	0	.0
	At least one missing discriminating variable	0	.0
	Both missing or out-of-range group codes and at least one missing discriminating variable	0	.0
	Total	0	.0
Total		244	100.0

Analysis Case Processing Summary can be used to determine whether the respondent (number of questions or columns in SPSS) is valid (valid) to be processed by a logical table of any missing data. Table 1 explained that all respondents are valid or can be said to be 100% valid, and it can be concluded that there is no incomplete data.

Table 2. Group Statistics

GPA		**Mean**	**Std. Deviation**	**Valid N (listwise)**	
				Unweighted	**Weighted**
GPA<3,5	AGE	21.79	1.989	68	68.000
	STUDY HOURS	4.66	2.341	68	68.000
	IQ	95.50	9.875	68	68.000
	SEMESTER	5.69	2.248	68	68.000
	GENDER	1.54	.502	68	68.000
	UNIVERSITY	1.34	.477	68	68.000
GPA≥ 3,5	AGE	21.43	1.083	176	176.000
	STUDY HOURS	6.01	3.189	176	176.000
	IQ	105.74	9.347	176	176.000
	SEMESTER	5.32	1.840	176	176.000
	GENDER	1.77	.420	176	176.000
	UNIVERSITY	1.22	.413	176	176.000

Total	AGE	21.53	1.401	244	244.000
	STUDY HOURS	5.64	3.034	244	244.000
	IQ	102.89	10.534	244	244.000
	SEMESTER	5.42	1.964	244	244.000
	GENDER	1.71	.455	244	244.000
	UNIVERSITY	1.25	.434	244	244.000

Table 2 presents the average differences for each independent variable between the GPA < 3.5 and GPA ≥ 3.5 groups. It can be seen that study hours, IQ, gender, and type of university show significant average differences between the two groups. Specifically, the GPA < 3.5 group has an average study hours of 4.66, significantly lower than the 6.01 in the GPA ≥ 3.5 group. Similarly, the average IQ score for the GPA < 3.5 group is 95.50, while the GPA ≥ 3.5 group reaches 105.74. For gender, the GPA < 3.5 group had an average of 1.54, compared to 1.77 for the GPA ≥ 3.5 group. Finally, university type showed an average of 1.34 for the GPA < 3.5 group and 1.22 for the GPA ≥ 3.5 group.

Based on these substantial differences, it can be concluded that study hours (X2), IQ (X3), gender (X5), and type of university (X6) are factors that significantly differentiate between groups of students with a GPA below 3.5 and a GPA of 3.5 or higher. Conversely, other categories that did not show sufficiently large average differences were considered insignificant or invalid in distinguishing between the two GPA groups.

Table 3. Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
AGE	.986	3.313	1	242	.070
STUDY HOURS	.960	10.069	1	242	.002
IQ	.809	57.019	1	242	.000
SEMESTER	.993	1.774	1	242	.184
GENDER	.949	12.984	1	242	.000
UNIVERSITY	.984	3.946	1	242	.048

Table 3 shows each independent variable based on the F Test, whether there is a significant comparison between the two discriminant categories, namely the "GPA <3.5" and "GPA ≥ 3.5" categories. If Sig. <0.05, then there is a significant difference between groups. The variables of Study Time (X2), IQ (X3), Gender (X5) and University (X6) have significance values, namely Study Time (X2) of 0.002, IQ (X3) of 0.000, Gender (X5) of 0.000 and University (X6) of 0.048 or less than 0.05. This shows that there are significant differences between groups. Therefore, it is reasonable to assume that Study Time(X2), IQ(X3), Gender(X5) and University(X6) are influential factors in this study.

Table 4. Entered/Removed

				Min. D Squared			
					Exact F		
Step	**Entered**	**Statistic**	**Between Groups**	**Statistic**	**df1**	**df2**	**Sig.**
1	IQ	1.162	IPK<3.5 and IPK≥3.5	57.019	1	242.000	8.797E-13
2	Study Time	1.668	IPK<3.5 and IPK≥3.5	40.750	2	241.000	5.693E-16

3	University	2.157	IPK<3.5 and IPK≥3.5	34.979	3	240.000	8.626E-19
4	Gender	2.335	IPK<3.5 and IPK≥3.5	28.277	4	239.000	3.064E-19

Table 4 listing the variables that are suitable for incorporating the six factors tested into the discriminant equation. From the six factors tested, we can see that four of them have sufficient or strong significance, thereby affecting a person's GPA. Meanwhile, the other two factors did not meet the criteria because they did not have sufficient significance, thereby not strongly affecting a person's GPA. So, it can be concluded that the variables of IQ (X3), Study Time (X2), University (X6) and Gender (X5) are variables that are included in the equation model or discriminant equation. While the other two variables, namely Age (X1) and Semester (X4) do not enter the discriminant equation model.

Table 5. Variable in the Analysis

Step		Tolerance	Sig. of F to Remove	Min. D Squared	Between Groups
1	IQ	1.000	.000		
2	IQ	.950	.000	.205	IPK<3,5 and IPK≥ 3,5
	STUDY HOURS	.950	.000	1.162	IPK<3,5 and IPK≥ 3,5
3	IQ	.932	.000	.480	IPK<3,5 and IPK≥ 3,5
	STUDY HOURS	.766	.000	1.262	IPK<3,5 and IPK≥ 3,5
	UNIVERSITY	.806	.000	1.668	IPK<3,5 and IPK≥ 3,5
4	IQ	.925	.000	.762	IPK<3,5 and IPK≥ 3,5
	STUDY HOURS	.766	.000	1.446	IPK<3,5 and IPK≥ 3,5
	UNIVERSITY	.805	.000	1.837	IPK<3,5 and IPK≥ 3,5
	GENDER	.992	.015	2.157	IPK<3,5 and IPK≥ 3,5

Table 5 explains the previous steps in the process of selecting variables to be added to the model individually. In this analysis, four variables significantly entered the model. In Step 1, IQ was the first predictor variable to be included because it showed very high significance ($p<0.001$), indicating its strong contribution. Then, in Step 2, STUDY HOURS were added to the model and also showed very strong significance ($p<0.001$). Next, UNIVERSITY was included in Step 3, maintaining high significance ($p<0.001$) alongside IQ and STUDY HOURS. Finally, in Step 4, the variable GENDER was added and also showed significance ($p=0.015$), although with a relatively smaller contribution compared to the previous three variables. Overall, these findings indicate that IQ, STUDY HOURS, UNIVERSITY, and GENDER are significant predictive factors in distinguishing GPA groups in this research sample.

Table 6. Variable Not in The Analysis

Step		Tolerance	Min. Tolerance	Sig. of F to Enter	Min. D Squared	Between Groups
0	AGE	1.000	1.000	.070	.068	IPK<3,5 and IPK≥ 3,5
	STUDY HOURS	1.000	1.000	.002	.205	IPK<3,5 and IPK≥ 3,5
	IQ	1.000	1.000	.000	1.162	IPK<3,5 and IPK≥ 3,5
	SEMESTER	1.000	1.000	.184	.036	IPK<3,5 and IPK≥ 3,5
	GENDER	1.000	1.000	.000	.265	IPK<3,5 and IPK≥ 3,5

	UNIVERSITY	1.000	1.000	.048	.080	IPK<3,5 and IPK≥ 3,5
1	AGE	.987	.987	.382	1.182	IPK<3,5 and IPK≥ 3,5
	STUDY HOURS	.950	.950	.000	1.668	IPK<3,5 and IPK≥ 3,5
	SEMESTER	1.000	1.000	.219	1.201	IPK<3,5 and IPK≥ 3,5
	GENDER	.992	.992	.008	1.341	IPK<3,5 and IPK≥ 3,5
	UNIVERSITY	.999	.999	.049	1.262	IPK<3,5 and IPK≥ 3,5
2	AGE	.973	.937	.175	1.719	IPK<3,5 and IPK≥ 3,5
	SEMESTER	.766	.728	.000	2.049	IPK<3,5 and IPK≥ 3,5
	GENDER	.992	.943	.014	1.837	IPK<3,5 and IPK≥ 3,5
	UNIVERSITY	.806	.766	.000	2.157	IPK<3,5 and IPK≥ 3,5
3	AGE	.909	.752	.785	2.159	IPK<3,5 and IPK≥ 3,5
	SEMESTER	.502	.502	.141	2.222	IPK<3,5 and IPK≥ 3,5
	GENDER	.992	.766	.015	2.335	IPK<3,5 and IPK≥ 3,5
4	AGE	.904	.751	.914	2.335	IPK<3,5 and IPK≥ 3,5
	SEMESTER	.501	.501	.172	2.392	IPK<3,5 and IPK≥ 3,5

Table 6 which is a table containing something contrary to the previous table that combines factors that will be individually excluded from the discriminant model. In this table consists of 4 steps, namely step 0 contains the six variables to be analyzed.

- In step 1 the variable IQ (X3) is eliminated and leaves five variables in it, this happens because the variable IQ (X3) enters the discriminant function model where the variable is contained in the Variable in The Analysis table.
- In step 2 the variable Study Time (X2) is eliminated and leaves four variables in it, this happens because the variable Study Time (X2) is included in the discriminant function model where the variable is contained in the Variable in The Analysis table.
- In step 3 the variable University (X6) is eliminated and leaves three variables in it, this happens because the variable University (X6) is included in the discriminant function model where the variable is contained in the Variable in The Analysis table.
- In step 4, the Gender variable (X5) is eliminated and leaves 2 variables in it, this happens because the Gender variable (X5) is included in the discriminant function model where the variable is contained in the Variable in The Analysis table.

Table 7. Result of Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.473[a]	100.0	100.0	.567
First 1 canonical discriminant functions were used in the analysis.				

Table 7 show a description of how variables are divided into one or more factors. From the table above, it can be concluded that canonical correlation measures how closely groups and discriminant scores are related (in this case there are two groups because there are two types of GPA). With a canonical correlation result of 0.567, the factors of Study Time (X2), IQ (X3), Gender (X5) and University (X6) can explain the difference in student achievement index by 56.7%, while the remaining 43.3% is influenced by other factors outside this study.

Table 8. Result of Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	Df	Sig.
1	.679	92.993	4	.000

Table 8 shows statistically significant differences between the two groups in the discriminant function based on the Chi-Square value. From the table above, it can be seen that the significant value is less than 0.05, which is 0.000. This means that the variables studied have differences between groups, so they can be used to determine how the categories differ from each other.

Table 9. Result of Canonical Discriminant Function Coefficients

	Function
	1
Study Hours	.237
IQ	.090
Gender	.623
University	-1.193
(Constant)	-10.154
Unstandardized coefficients	

Table 9 explain in discriminant analysis is used to create an equation function. Based on the table, the UNIVERSITY variable has the largest absolute coefficient (–1.193), indicating that this variable has the most dominant contribution to the discriminant function and is in the opposite direction to variables with positive coefficients. Next, GENDER also shows a significant contribution with a positive coefficient (0.623). Meanwhile, STUDY HOURS and IQ have smaller positive coefficients (0.237 and 0.090, respectively), indicating a lower but still positive contribution to the discriminant function. Finally, the value (Constant) of –10.154 is the intercept of the discriminant function. Overall, these coefficients can be used to construct a discriminant function equation that predicts group membership based on the values of the predictor variables.

Based on the unstandardized discriminant function coefficients from the *"Canonical Discriminant Function Coefficients"* table, the discriminant function equation can be formed as follows:

$$D = -10{,}154 + 0{,}237(X_2) + 0{,}090\ (X_3) + 0{,}623\ (X_5)\ +\ (-1{,}193)\ (X_6)$$

This equation is a mathematical model used to calculate the discriminant score (D) for each individual. This discriminant score will then determine membership in the GPA group (GPA < 3.5 or GPA ≥ 3.5) based on the values of the predictor variables: STUDY HOURS (X 2), IQ (X3), GENDER (X5), and UNIVERSITY (X6). In other words, this formula functions as a classification tool to predict an individual's GPA group.

Table 10. Result of Functions at Group Centroids

IPK	**Function**
	1
IPK<3,5	-1.102
IPK≥ 3,5	.426

Table 10 show that this table used to determine the collection limit points or limits that estimate the categories that fall into the "GPA <3.5" and "GPA ≥3.5" groups. From the table above, it can be seen that the Centroids value for the GPA <3.5 category is -1.102 and GPA ≥3.5 is 0.426. It is known c_0 to represent the GPA <3.5 group based on the average value of the discriminant, and c_1 to represent the GPA ≥3.5 group based on the average value of the discriminant. How to calculate the value of the separator, namely:

$$SCORE\ DIVIDER = \frac{N_1 \times C_0 + N_2 \times C_1}{N_1 + N_2}$$
$$= \frac{68 \times (-1{,}102) + 176 \times 0{,}426}{68 + 176}$$
$$= \frac{-74{,}936 + 74{,}976}{244}$$
$$= \frac{0{,}04}{244}$$
$$= 0{,}000$$

- *N = Number of samples or respondents belonging to the poor group*
- *N = Number of samples or respondents belonging to the good group*
- *C = Number of Function at Group Centroids in the poor group*
- *C = Number of Function at Group Centroids in the good group*

The grouping rules are;

- *Included in the "GPA <3.5" category, if the discriminant value (D) is lower than the separation value (0.000).*
- *Included in the "GPA ≥3.5" category, if the discriminant value (D) is higher than the separation value (0.000).*

Table 11. Classification Results

		IPK	Predicted Group Membership		Total
			IPK<3,5	IPK≥ 3,5	
Original	Count	IPK<3,5	54	14	68
		IPK≥ 3,5	35	141	176
	%	IPK<3,5	79.4	20.6	100.0
		IPK≥ 3,5	19.9	80.1	100.0
Cross-validated[b]	Count	IPK<3,5	54	14	68
		IPK≥ 3,5	35	141	176
	%	IPK<3,5	79.4	20.6	100.0
		IPK≥ 3,5	19.9	80.1	100.0

Table 11 used to show the accuracy of the estimated discriminant function. Generally, an accuracy of more than 50% is considered valid. From the table above, it can be seen that there are 68 students who basically got a place in the GPA <3.5 classification. While students who initially belonged to the GPA≥ 3.5 group amounted to 176 people and above. The initial precision of the discriminant model is 79.9% accurately arranged and 79.9% accurately cross-agreed groups when characterization, so this model is considered to have high precision. Because the accuracy value is more than 50%. Therefore, the cases of Student Achievement Index can be classified using this discriminant model.

Example Of Proof Of The Discriminant Formula

1. *A student named Rizal, known to study 10 hours per day, with an IQ of 110, male gender (1) and from a private university (1). Then PREDICT, does Rizal fall into the GPA < 3.5 group or into the GPA ≥ 3.5 group?*

   Answer:

   - $D = -10{,}154 + 0{,}237 \times (X_2) + 0{,}090 \times (X_3) + 0{,}623 \times (X_5) + (-1{,}193) \times (X_6)$
   - $D = -10{,}154 + 0{,}237 \times (10) + 0{,}090 \times (110) + 0{,}623 \times (1) + (-1{,}193) \times (1)$
   - $D = -10{,}154 + 2{,}37 + 9{,}9 + 0{,}623 + (-1{,}193)$
   - $D = 1{,}546$

- 1,546 > 0,000 = Including to group GPA ≥ 3.5

2. *A student named Budi, known to study 4 hours per day, with an IQ of 95, male gender (1) and from a private university (1). So, PREDICTION, does Budi fall into the GPA < 3.5 group or into the GPA ≥ 3.5 group?*

   Answer:

- $D = -10{,}154 + 0{,}237 \times (X_2) + 0{,}090 \times (X_3) + 0{,}623 \times (X_5) + (-1{,}193) \times (X_6)$
- $D = -10{,}154 + 0{,}237 \times (4) + 0{,}090 \times (95) + 0{,}623 \times (1) + (-1{,}193) \times (1)$
- $D = -10{,}154 + 0{,}948 + 8{,}55 + 0{,}623 + (-1{,}193)$
- $D = 1{,}963$
- 1,963 < 0,000 = Including to group GPA < 3,5

CONCLUSION

With the results of the analysis in the discussion above, the author can conclude that, the variables of duration of study hours, IQ, Gender and University get a significant value. This shows that there is a significant difference between groups. While age and semester have less significant value so there is no difference between groups. In conclusion, the most influential factors are study hours, IQ, Gender, and University.

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