

STUDENT GRADUATION LEVEL PREDICATE MODEL IN STUDY PROGRAM USING MULTILEVEL ORDINAL LOGISTIC REGRESSION

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Abstracts. *Multilevel ordinal logistic regression analysis is one type of regression modeling has hierarchical structure data when response variables is ordinal scale. Predicate level of student graduation is data with hierarchical structure with students nested in their study program. This paper purpose to explain factors influence the level of student graduation predicate and variance from level the study program. The data used in this research from the database of academic applications of universities in Baubau City. The results showed the best model was multilevel model with random slope effect of student age. Explanatory variables that influence the model are gender, regional origin status, and education financing status with variance level the study programs of 0.742 and variance the student age of 0.052. Graduates have a great probability get a high level of predicate are female students, most come from outside Baubau City and financed by their parents.*

Keywords : *graduation predicate level, ordinal logistics regression, multilevel ordinal logistics regression.*

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1. INTRODUCTION

Education in Indonesia consists of formal, non-formal and informal education. Formal education is a structured and tiered educational path consisting of basic, middle, and higher education [1]. Higher education is a level of education after middle education which includes diploma, bachelor or undergraduate, master, doctoral, professional, and specialist programs, which organized by universities, either state universities or private universities based on the culture of Indonesian nation [2]. Time and load implementation programs in higher education are different, in the undergraduate program maximum of seven years academic with student learning load minimal at 144 credits. Students who have passed the graduation can get a predicate of graduation based on GPA value, as follows: 1) praise or cum laude category with GPA of 3.51 to 4.00; 2) very satisfying category with GPA of 3.01 to 3.50; and satisfying category with GPA of 2.76 to 3.00 [3]. Whereas students graduated with GPA below 2.76, no given predicate graduation.

Many factors can influence a student's graduation predicate such as faculty, gender, school status, regional origin, father's occupation, and mother's occupation [4], [5]. These factors are into four hierarchical structure factors, as follows: 1) individual factors; 2) family factors; 3) environmental factors; and 4) institutional factors [6], [7]. Hierarchical structure data is individual data nested in groups, where individuals in the same group have characteristics that tend to same. Multilevel modeling is a proper analysis method to use for this. In general, the level of structure used is not limited, although usually only two levels are used, namely the low level and high level [8]. In addition to show variance of the level, multilevel modeling can also show the correlation between two individuals.

The predicate level of student graduation is categorical data and measured by ordinal scale. Ordinal scale is also called a rating scale and usually has more than two categories or ratings. One the analyzes used in analyzing a relationship where ordinal response variables with hierarchical structure is ordinal logistic regression analysis. In education, researchers such as [9], [10], [11] have used multilevel ordinal logistic regression in their analysis. However, the three of them did not examine the relationship to student graduation predicate. On the other hand, the researchers emphasize the variance given from each level and the use of multilevel ordinal models is better in explaining the effect of the explanatory variables than the usual ordinal regression model.

Baubau City, which is located on Buton Island, Southeast Sulawesi Province, Indonesia, is one of the cities that is the center of education for the Buton Island region because it has 8 university institutions [12]. The university institutions in Baubau City that have the largest number of students are the University of Dayanu Ikhsanuddin, University of Muhammadiyah Buton, and YPIQ Baubau Islamic College [13].

Based on the description that has been presented, the purpose of this paper is to analyze the factors influence of predicate graduation students at university using multilevel ordinal logistic regression analysis. The level used is individual grouped between study programs. The factors are focused on gender, age of graduates, regional origin status, education financing status, number of graduates from study programs, amount of education payment from study programs, and learning methods used by study programs.

2. RESEARCH METHODS

The method used in this paper is apply multilevel ordinal logistic regression model to the predicate of graduation students in 2020 and 2021 year at the Baubau City College. The universities in question are University of Dayanu Ikhsanuddin (Unidayan), University of Muhammadiyah Buton (UM Buton), and YPIQ Islamic College (STAI YPIQ). The data used were 3107 graduates, which were obtained from database the application of each university. In this paper, the level structure is divided into two levels, low level for the individual and high level for the study program. Factors that are thought to influence student graduation predicate include gender (X_1), age of graduates (X_2), regional origin status (X_3), and education financing status (X_4) at the individual level, well as number of graduates of (Z_1), amount of education payment (Z_2), and learning methods (Z_3) at the study program level.

2.1. Analysis Regression Ordinal Logistics

Ordinal logistic regression is type of regression that models the relationship between ordinal response variable and the numerical and categorical explanatory variables. Suppose Y is an ordinal response variable with category C and $x' = (1, 2, \dots, x_j)$ is vectors of explanatory variable, then the probability of category c at the value of x can be expressed with [10]:

$$P[Y \leq c|\mathbf{x}] = \pi_c(\mathbf{x}) \quad (1)$$

and the cumulative probability are:

$$P[Y \leq c|\mathbf{x}] = \pi_1(\mathbf{x}) + \dots + \pi_c(\mathbf{x}) \quad (2)$$

The cumulative model logit is defined as:

$$\begin{aligned} L_c(\mathbf{x}) &= \text{logit}(P[Y \leq c|\mathbf{x}]) \\ &= \log\left(\frac{P[Y \leq c|\mathbf{x}]}{1 - P[Y \leq c|\mathbf{x}]}\right) \\ &= \log\left(\frac{\pi_1(\mathbf{x}) + \dots + \pi_c(\mathbf{x})}{\pi_{c+1}(\mathbf{x}) + \dots + \pi_C(\mathbf{x})}\right) \\ &= \alpha_c + \mathbf{x}'\boldsymbol{\beta} \end{aligned} \quad (3)$$

with $c = 1, \dots, C - 1$ and $\alpha_c = \alpha_1, \dots, \alpha_{C-1}$ is the threshold model and $\boldsymbol{\beta}$ is vector coefficient regression.

The parameter estimation method used in this model is maximum likelihood method with the assumption of independent observations [10]. In its application to find an estimator, the likelihood function to transform into natural logarithm (\ln) as follows:

$$L(\boldsymbol{\beta}) = \sum_{i=1}^n \sum_{c=1}^C y_{ci} \ln [\pi_c(\mathbf{x})] \quad (4)$$

Seen that $\pi_c(\mathbf{x})$ is a function of the parameters $\boldsymbol{\beta}$.

2.2. Analysis Regression Multilevel Ordinal Logistics

Hierarchical structured data with ordinal response variables can be modeled using multilevel ordinal logistic regression analysis. According to Hedeker, suppose there is C an ordinal category in the response variable and explanatory variable vector is $\mathbf{x}' = (\mathbf{1}, \mathbf{2}, \dots, \mathbf{x}_p)$, then the probability of a category at the value of \mathbf{x} can be expressed by [10]:

$$P[Y_{ij} \leq l|\mathbf{x}] = \pi_{ijl}(\mathbf{x}) \quad (5)$$

and probability cumulative defined:

$$P_{ijc} = P(Y_{ij} \leq c|\mathbf{x}) = \sum_{l=1}^c \pi_{ijl}(\mathbf{x}) \quad (6)$$

with $l = 1, 2, \dots, c$ and $c = 1, 2, \dots, C - 1$.

The cumulative probability of the multilevel logistic model is given in cumulative logit as:

$$\begin{aligned} L_c(\mathbf{x}) &= \text{logit}(P[Y_{ij} \leq c|\mathbf{x}]) \\ &= \log\left(\frac{P_{ijc}}{1 - P_{ijc}}\right) \\ &= \gamma_c + [\mathbf{x}'_{ij}\boldsymbol{\beta} + v_j] \end{aligned} \quad (7)$$

with $i = 1, 2, \dots, n_j$; $j = 1, 2, \dots, k$; and $c = 1, 2, \dots, C - 1$, where n_j is the number of individuals in the group j and k is the number of groups. Next $\boldsymbol{\beta}$ is a vector of regression coefficients and v_j is a random effect at the assumed second level of normally distributed $N(0, \sigma_v^2)$. Method parameter estimation used in this model is *maximum likelihood* with iteration [10].

2.3. Parameter Test Significance

The results of parameter estimation need to be tested for parameter significance. One method to test its significance is Likelihood Ratio Test (LRTs). The LRTs test is used to test whether the explanatory variable has a simultaneous effect on the response variable or not by comparing the loglikelihood values of each model being compared [14]. Statistics test used are:

$$D = -2 \log\left(\frac{L_0}{L_1}\right) \quad (8)$$

where L_0 is value *likelihood* in the model without variable explanation and L_1 is likelihood value in the model with involve explanatory variable.

After obtaining the results of the overall significance test, then each explanatory variable was tested to determine which explanatory variable had an effect. Wald's test is used to test whether each explanatory variable partially has a significant effect on the response variable or not [14]. Statistics test used are:

$$W_k = \left[\frac{\hat{\beta}_k}{\widehat{SE}(\hat{\beta}_k)} \right]^2 \quad (9)$$

where $\hat{\beta}_k$ is the parameter estimator of k , and $\widehat{SE}(\hat{\beta}_k)$ is standard deviation from $\hat{\beta}_k$ for $k = 1, 2, \dots, p$.

2.4. Evaluation Classification and Coefficient Interpretation

Evaluation of classification is an evaluation to see the probability of misclassification carried out by a classification function, where a good classification function is determined with a small error value. The method that can be used to determine the classification error is to calculate the value of the Apparent Error Rate (APER) using a classification table that states the proportion of a sample [15]. Something method classification said have level good accuracy if have small APER value or level high accuracy.

Coefficient interpretation purpose to determine the functional relationship between the explanatory variable and the response variable and to explain the change in the response variable caused by the explanatory variable. Something method that can be used for categorical response variables is the odds ratio (OR) value. $OR > 1$ indicates that probability of an event occurring in the first group is greater than that of the second group, while $OR < 1$ indicates that probability of an event occurring in the first group is smaller than that of the second group [16].

2.5. Analysis Step

Steps analysis in paper this is following as:

- 1) Performing model building at level one with fixed effect structure.
- 2) Testing the significance of the model by comparing the significance values to choose the best model from the fixed effect structure at level one.
- 3) Conducting model formation at level two by adding random slope effects from individual level explanatory variables.
- 4) Testing the significance of the model by comparing the significance value of the best level one model with the level two model to select the best multilevel model.
- 5) Testing the parameter significance of the best multilevel model. If there is an explanatory variable that does not significantly affect the response variable, then the model is reduced and then the significance test of the model is carried out again.
- 6) Testing the accuracy of the model with the APER value.
- 7) Explaining parameter interpretation based on OR value.

The data analysis process was carried out using the STATA program.

3. RESULTS AND DISCUSSION

3.1. Description of Predicate Graduation

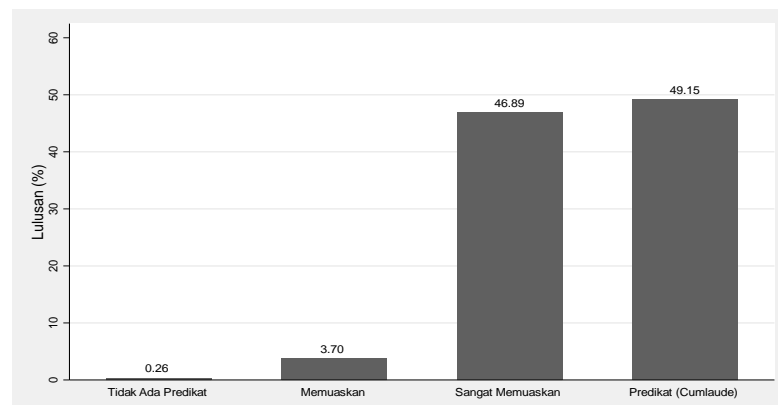


Figure 1. Percentage of Student Graduation Predicate in Baubau City 2020-2021

The percentage of student graduation rates in 2020 and 2021 at universities in Baubau City can be seen in Figure 1. Most of the students graduates in Baubau City get the cumlaude predicate (49.15%) and very

satisfactory predicate (46.89%). While the other categories of predicate are relatively small, that is 3.70% of graduates who get satisfactory predicate and the remaining 0.26% are graduates who are not get the predicate.

Description of student graduation predicates for each study program in Baubau City can be seen in Table 1. Visible that STAI YPIQ graduates come from 3 study programs, UM Buton graduates come from 11 study programs, and Unidayan graduates come from 15 study programs.

Table 1. Predicate of student graduation for year 2020-2021 in Baubau City is based on study program

Study Program	Predicate of Student Graduation (%)			
	No Predicate	Satisfying	Very Satisfactory	Cumlaude
STAI YPIQ_BPI	-	-	84.44	15.56
STAI YPIQ_PAI	-	-	50.75	49.25
STAI YPIQ_PIAUD	-	-	83.33	16.67
Mean	-	-	72.84	27.16
UM BUTON_AGB	-	-	23.53	76.47
UM BUTON_AKT	-	-	18.88	81.12
UM BUTON_BK	-	4.26	58.51	37.23
UM BUTON_HKAS	-	-	36.36	63.64
UM BUTON_IHKM	-	-	33.33	66.67
UM BUTON_IPEM	1.72	22.32	24.89	51.07
UM BUTON_PAI	-	-	22.35	77.65
UM BUTON_PBIO	-	-	63.08	36.92
UM BUTON_PBSI	-	-	35.00	65.00
UM BUTON_PGPAUD	-	-	14.06	85.94
UM BUTON_TSPL	-	-	74.55	25.45
Mean	1.72	13.29	36.78	60.65
UNIDAYAN_AGT	-	6.25	18.75	75.00
UNIDAYAN_AKT	-	6.02	46.99	46.99
UNIDAYAN_BDP	-	6.25	43.75	50.00
UNIDAYAN_IAN	-	2.27	59.09	38.64
UNIDAYAN_IHKM	-	3.80	46.84	49.37
UNIDAYAN_KESMAS	-	8.99	62.92	28.09
UNIDAYAN_MNJ	1.08	8.60	51.61	38.71
UNIDAYAN_PBING	-	-	41.67	58.33
UNIDAYAN_PEKON	-	-	26.53	73.47
UNIDAYAN_PMTK	-	1.15	44.83	54.02
UNIDAYAN_PSOR	-	1.67	66.67	31.67
UNIDAYAN_SOSIO	-	2.44	81.71	15.85
UNIDAYAN_TIK	-	1.87	53.27	44.86
UNIDAYAN_TMS	-	6.45	80.65	12.90
UNIDAYAN_TSPL	2.97	21.78	65.35	9.90
Mean	2.03	5.96	52.71	41.85

Most of the STAI YPIQ graduates get a very satisfactory predicate and there were no graduates who obtained a predicate below it. While most of the UM Buton graduates get a cumlaude predicate, there still graduates who did not get the predicate, that the from the Government Science study program. Whereas most of the Unidayan graduates get the very satisfactory predicate, there still 2 study programs whose graduates were not get the predicate.

3.2. Multilevel Ordinal Logistics Regression Analysis

Multilevel ordinal logistic regression analysis required several steps, that is selecting a fixed effect structure model, selecting random slope effect model, and selecting the best final model. The parameter estimation method used is maximum likelihood. First step in selecting a fixed effects structure model is to build a model like the following:

- 1) Model 1 (M.1) is model without explanatory variable.
- 2) Model 2 (M.2) is model with all explanatory variable from level-1.
- 3) Model 3 (M.3) is model with all explanatory variable from level-1 and one explanatory variable from level-2 that is number of graduates.
- 4) Model 4 (M.4) is model with all explanatory variable from level-1 and all explanatory variable from level-2.

The results of significance test the comparison fixed effect structure model were carried out with LRTs test presented in Table 2. Where H_0 : there was no significant difference between the two models, and H_1 : there was a significant difference between the two models at the significance level $\alpha = 5\%$ and the critical area to reject H_0 if the p-value less than α .

Table 2. Results of significant comparison test the fixed effect structure model.

Model	LogLik	LRTs	p-value	Decision
M.1	-2359.96			
M.1 with M.2	-2287.40	145.13	0.000	H_0 rejected
M.2 with M.3	-2287.24	0.33	0.565	H_0 accepted
M.3 with M.4	-2285.97	2.52	0.283	H_0 accepted

Based on Table 2, can be concluded that M.2 model or fixed effects structure model with all explanatory variables from level-1 was chosen the best model fixed effect structure because it has p-value less than 0.05. After getting the best fixed effect structure model, next step is to build a random slope model by adding random slope effect. In constructing the random slope model, fixed effect of each level-1 explanatory variable is added to slope effect into the best model of fixed effects as follows:

- 1) Model 1 (M.2) is best fixed effect structure model.
- 2) Model 2 (M.2-1) is fixed effect structure model and random slope gender (X_1).
- 3) Model 3 (M.2-2) is fixed effect structure model and random slope age (X_2).
- 4) Model 4 (M.2-3) is fixed effect structure model and random slope regional origin status (X_3).
- 5) Model 5 (M.2-4) is fixed effect structure model and random slope education financing status (X_4).

Table 3. Results of significance comparison test the random slope model

Model	LogLik	LRTs	p-value	Decision
M.2	-2287.40			
M.2 with M.2-1	-2284.36	6.09	0.014	H_0 rejected
M.2 with M.2-2	-2276.89	21.02	0.000	H_0 rejected
M.2 with M.2-3	-2284.84	5.13	0.024	H_0 rejected
M.2 with M.2-4	-2287.38	0.04	0.845	H_0 accepted

Table 3 is result of significance test comparison the model in selecting the multilevel random slope effect model. Can be concluded that the best multilevel random slope effect model is the M.2-2 model, that is fixed effect structure model and random slope for the age category of graduates (X_2) because the p-value is smaller than the M.2-1 and M.2-3 model. Next, to estimate the parameters of best multilevel ordinal logistic regression model with fixed effect structure and random slope. The results of estimation and significance testing the parameters are presented in Table 4. Where H_0 : there is no significant effect, and H_1 : there is a significant effect on the significance level of $\alpha = 5\%$ with critical area to rejects H_0 if the p-value less than α .

Table 4. Results and testing parameters of multilevel ordinal logistic regression model

Variable	Parameter	Coefficient	z	p-value	Decision
	γ_{00} [Satisfying]	-7.509	-11.550	0.0000	H_0 rejected
	γ_{00} [Very Satisfying]	-4.651	-8.420	0.0000	H_0 rejected
	γ_{00} [Cumlaude]	-0.818	-1.510	0.1312	H_0 accepted
X_1	β_1 [Female]	0.702	7.930	0.0000	H_0 rejected
X_2	β_2 [20 - 24 years]	0.290	1.290	0.1967	H_0 accepted
	β_2 [25 - 29 years]	0.242	0.990	0.3224	H_0 accepted
	β_2 [30 - 34 years]	-0.049	-0.160	0.8713	H_0 accepted
	β_2 [≥ 35 years]	-0.006	-0.020	0.9848	H_0 accepted
X_3	β_3 [Outside Baubau]	-0.429	-4.830	0.0000	H_0 rejected
X_4	β_4 [Own Pay]	-1.711	-3.550	0.0004	H_0 rejected
	β_4 [Parental Pay]	-1.062	-2.230	0.0260	H_0 rejected
W_j	v_{0j} [Study program]	0.719	2.840	0.0045	H_0 rejected
$W_j:X_2$	v_{1j} [Age nested in the study program]	0.046	2.240	0.0250	H_0 rejected

Based on Table 4, it is known that variables gender (X_1), regional origin (X_3), and education financing status (X_4) have a significant influence on the graduation predicate because p-value of the parameter less than 0.05. However, there is one explanatory variable in the fixed effect structure does not have significant

influence on the graduation predicate because p-value of all parameters is greater than 0.05, that is variable age of students (X_2). Because there are explanatory variables do not influence the response variable, it is necessary to reduce the model by eliminating the explanatory variable, that is eliminating the age variable (X_2) from the fixed effect structure and then to comparing with the model before the reduction. Results of significance test from comparison the two models are presented in Table 5.

Table 5. Results of significance comparison test the reduction model

Model	LogLik	LRTs	p-value	Decision
Reduction	-2265.26			
M.2-2	-2262.43	5.67	0.225	H_0 accepted

Based on Table 5, can be concluded the best final model of multilevel ordinal logistic regression selected is the reduced model because the p-value is greater than 0.05. Results of estimation and testing parameters the best final model or reduced model are presented in Table 6.

Table 6. Results of significance test the final model

Variable	Parameter	Coefficient	t count	p-value	Decision
	γ_{00} [Satisfying]	-7.789	-12.470	0.0000	H_0 rejected
	γ_{00} [Very Satisfying]	-4.934	-9.470	0.0000	H_0 rejected
	γ_{00} [Cumlaude]	-1.109	-2.180	0.0295	H_0 rejected
X_1	β_1 [Female]	0.706	7.980	0.0000	H_0 rejected
X_3	β_3 [Outside Baubau]	-0.427	-4.820	0.0000	H_0 rejected
X_4	β_4 [Own Pay]	-1.718	-3.580	0.0003	H_0 rejected
	β_4 [Parental Pay]	-1.033	-2.180	0.0294	H_0 rejected
W_j	v_{0j} [Study program]	0.742	2.840	0.0044	H_0 rejected
$W_j:X_2$	v_{1j} [Age nested in the study program]	0.052	2.310	0.0208	H_0 rejected

Based on Table 6, can be seen that there are no explanatory variables that do not have significant influence on the graduation predicate in Baubau City on 2020-2021 according the level of study program with random slope of graduate age. This result also shows there are differences the variance of predicate of student graduates in study program at each university with variance value of 0.742. So from the final model, equation model can be written following:

$$\widehat{L}_c(x) = \beta_{0j} + 0.706X_{1i}(1) - 0.427X_{3i}(1) - 1.718X_{4i}(2) - 1.033X_{4i}(3) \quad (10)$$

where $\beta_{0j} = \gamma_c + 0.052W_{ij}X_{2ij} + v_{0j}$. Probability cumulative for every category predicate graduation could obtained with equality following:

$$[Y \leq c|x] = \frac{1}{1 + \exp(-\widehat{L}_c(x))} \quad (11)$$

3.3. Evaluation Classification

The accuracy classification of multilevel ordinal logistic regression final model can be seen in Table 7. Percentage of accuracy in the final model is 67.72% and APER value is 32.28%. Most the predicate of graduation students are classified in the higher categories, that is very satisfying and cumlaude predicate. This is accordance with the description of data, most the graduates in Baubau City to get a very satisfactory and cumlaude graduation predicate.

Table 7. Percentage of classification accuracy the final model

Actual	Prediction				Accuracy (%)
	No Predicate	Satisfying	Very Satisfactory	Cumlaude	
No Predicate	0	0	7	1	0.00
Satisfying	0	0	104	11	0.00
Very Satisfying	0	2	1028	427	70.56
Cumlaude	0	0	451	1076	70.46
Overall classification accuracy (%)					67.72
APER (%)					32.28

This is also because one of the most influential explanatory variables, for example on gender variable, where the greater number of female graduates, the graduation predicate will tend to get a higher or better predicate category.

3.4. Coefficient Interpretation

Interpretation of coefficients the multilevel ordinal logistic regression final model using the odds ratio value with a 95% confidence level is shown in Table 8.

Variable	Estimate Odds Ratio	CL 95% for OR	
		Lower	Upper
X_1 [Female]	2.025	1.703	2.409
X_3 [Outside Baubau]	0.652	0.548	0.776
X_4 [Own Pay]	0.179	0.070	0.459
X_4 [Parental Pay]	0.356	0.141	0.901

Based on Table 8, it found that female graduates have probability to get a better graduation predicate, that is 1.703 to 2.409 times compared to male graduates in their study program. Furthermore, for graduates from outside Baubau City, the probability of getting a higher predicate less than graduates from Baubau City with confidence interval of 0.548 to 0.776. And for the status of education financing in the Own-payment category, the probability of getting a higher predicate less than of Parental-payment with confidence interval of 0.070 to 0.459.

4. CONCLUSIONS

1. The explanatory variables that influence of graduation predicate students in Baubau City are gender (X_1), regional origin status (X_3), and education financing status (X_4) with variance between study programs of 0.742 and variance of random slope variable is 0.052.
2. The equation of the multilevel ordinal logistic regression model for predicate level of graduation students in the study program as follows:

$$\widehat{L_c}(x) = \beta_{0j} + 0.706X_{1i}(1) - 0.427X_{3i}(1) - 1.718X_{4i}(2) - 1.033X_{4i}(3)$$
 where $\beta_{0j} = \gamma_c + 0.052W_{ij}X_{2ij} + 0.742$.
3. Classification accuracy value of the final model was obtained at 67.72% with results the classification of graduation predicate tending to be classified in higher predicate categories. While the estimated odds ratio value obtained for the gender variable is the largest compared to other variables.

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