Závislosti mezi výsledky studentů během studia a výsledky u Státních závěrečných zkoušek

Correlation between Students' Results Obtained during their Studies and at Final State Examinations

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Abstract:
Purpose of the article: The objective of the article is to provide information regarding of the evaluation of the knowledge students prove to have during their studies and show at final state examinations before the Board on the one hand, and the evaluation of bachelor degree theses by supervisors and consultants against the results of the thesis defence before the Board as part of the final state examination.
Methodology/methods: Mathematical statistics, testing of statistical hypothesis, correlation analysis
Scientific aim To find the correlation between students' results obtained during their studies and at final state examinations as a results of evaluation of final state examination boards.
Findings: The findings we have ascertained show that: Students' knowledge accomplished during their studies correlates with the Board's evaluation more than on average. The level of students' bachelor degree theses correlates with the Board evaluation more than on average. Nearly all the Boards evaluated student performances more strictly than it was during their studies. Nearly all the Boards evaluated the defence of bachelor degree theses more strictly than the supervisors and consultant did.
Conclusion: The results of chapter 4 show the following: Nearly all FSE Boards evaluated defences of student bachelor degree theses in MI subject more strictly than these theses were evaluated by their supervisors and opponents. Nearly all FSE Boards evaluated student knowledge in the Debate more strictly than the same knowledge was evaluated in the course of the students' studies as is expressed by the Weighted Averages.

Keywords: students' results, bachelor degree thesis, final state examination, hypothesis testing, correlation analysis

JEL Classification: A20, C12

Introduction

Students' results before and after the Final State Examination may be different. The reasons may include higher demand of the Board, nervousness of the students, their inability to "sell" their knowledge and quality of their bachelor degree theses, as well as other factors (Hendl, 2009; Chráska, 2007).

The purpose of this article is to inform about a project which used methods of mathematical statistics to assess levels of evaluation of student performance by the Board at the Final State Examination.

The following correlations were investigated:

A) Correlation between evaluations of bachelor degree theses of students by their supervisors and opponents and evaluations of defence of these theses by the Board.
B) Correlation between study results of the students during their course – characterised with weighted average – and assessment of their knowledge by the Board in the Debate.

The article used data of protocols of 14 Final Bachelor Degree State Examination Boards at the Faculty of Business and Management in the academic year 2010/11, who examined together 131 students majoring in Manager Informatics.

After completion of the Final Bachelor Degree State Examinations (hereinafter FSE) student evaluation by each FSE Board was entered in a table.

A sample record is presented in Table 1, showing evaluation of students by one FSE Board.

Data in the individual columns of the table have the following meaning:

- The leftmost column include names of the students examined by the Board (here the names are replaced with Student.)
- The *WA* column shows the Weighted average result of each student, *i.e.* the mean of all marks from examinations in all subjects passed by the student in the course of his/her bachelor degree course.
- The column entitled Supervisor includes the student's bachelor degree thesis evaluation by his/her supervisor.
- The column entitled Opponent includes the student's bachelor degree thesis evaluation by his/her opponent.
- The column entitled Defence includes the result of the student's defence of his/her bachelor degree thesis in front of the FSE Board.
- The column entitled Debate includes evaluation of the student's knowledge in the Debate where knowledge of the students is assessed across selected domains known to the students in advance. The Debate follows successful bachelor degree thesis defence. If the defence is classified with "F" then the FSE of the student is discontinued.
- The last column of the table entitled Overall result shows all marks of the student after FSE taken together.

The second to fourth columns of the table show the students' interim results obtained in the course

Table 1. Table of Student Results by one FSE Board.

Name	WA	Supervisor	Opponent	Defence	Debate	Overall results
Student1	2.11	B	A	B	B	B
Student2	1.76	B	A	B	E	D
Student3	1.60	B	A	B	C	C
Student4	2.21	C	C	B	D	C
Student5	2.13	B	B	B	C	B
Student6	1.81	A	A	A	C	C
Student7	1.95	B	C	D	C	D
Student8	1.41	B	A	B	B	B
Student9	1.81	B	A	B	C	C
Student10	1.94	C	A	B	C	C

Source: Final State Examinations Faculty of Business and Management, 2011.

Table 2. Table of ECTS classification and the corresponding numerical classification.

ECTS classification	A	B	C	D	E	F
Numerical classification	1	1.5	2	2.5	3	4

Source: Studijní programy pro akademický rok 2012/2013.

Table 3. Variants of tests with selective mean value of normal distribution.

H_0	H_1	Critical area W_α
$\mu \le \mu_0$	$\mu > \mu_0$	$\left\{t = (\bar{x} - \mu_0) / s\sqrt{n} : t \ge t_{1-\alpha}(n-1)\right\}$
$\mu = \mu_0$	$\mu \ne \mu_0$	$\left\{t = (\bar{x} - \mu_0) / s\sqrt{n} : \lvert t\rvert \ge t_{1-\alpha/2}(n-1)\right\}$
$\mu \ge \mu_0$	$\mu < \mu_0$	$\left\{t = (\bar{x} - \mu_0) / s\sqrt{n} : t \le t_{1-\alpha}(n-1)\right\}$

Source: Kropáč, 2009; Hindls, 2004.

of their bachelor degree studies. Further columns to the right show their FSE results.

To be able to assess the results from the numerical point of view, the evaluations based on the classification scale ECTS were transferred to the respective numerical values as shown in Table 2.

1. Applied methods of mathematical statistics

To assess the difference between the students' results before and after FSE and the results of evaluations by the individual Boards the following methods of mathematical statistics were used (Rohlíková *et al*. 2012).

a) To describe the difference between evaluation of the students' bachelor degree theses by their supervisors and opponents on the one side and the FSE Board on the other side we introduced a random quantity marked "*Y*".
To describe the difference between students' knowledge expressed by Weighted Average and evaluation of their knowledge in the Debate we introduced a random quantity marked "*X*".
Selective means and selective spreads of these random quantities were calculated by the following formulas:

$$\bar{x} = \sum_{i=1}^{n} x_i,\ s_x^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2,$$

$$\bar{y} = \sum_{i=1}^{n} y_i\ ,\ s_y^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2\ , \qquad (1)$$

where x_i and y_i, i=1,2,…,n were the observed values of these random quantities and n was the size of the dataset (Budíková *et al.*, 2005).

b) To assess statistical significance of the differences between the numerical values of the means and the assumed value we applied the statistical test with the selective mean of normal distribution.
Test variants formulated by zero (H_0) and alternative hypotheses (H_1), and critical areas (W_α, where t is the test criterion) are shown in Table 3. The values $t_{1-\alpha}(n-1)$ and $t_{1-\alpha/2}(n-1)$ are equivalent deviates of Student distribution.

c) To express the correlation between evaluation of the student bachelor degree thesis by the supervisor and the opponent on the one side and the FSE Board on the other side, or between knowledge of the students expressed by Weighted Average and evaluation of the knowledge in the Debate we used correlation coefficients.
For random quantities marked U and V with their values u_i and v_i, where i=1,2,…,n, their *correlation coefficient* was calculated using the following formula (Anděl, 2011):

$$r_{UV} = \frac{C_{UV}}{s_U s_V}\ , \qquad (2)$$

where s_U and s_V are selective spreads and C_{UV} is selective covariance, for which:

$$C_{UV} = \frac{1}{n-1}\sum_{i=1}^{n}(u_i - \bar{u})(v_i - \bar{v}). \qquad (3)$$

On the basis of the value of $|r_{UV}|$ it is possible to characterise the value of stochastic linear correlation of random quantities U and V as follows: This correlation is considered very weak when $|r_{UV}|$ is close to zero, medium when$|r_{UV}|$ is close to one half and very strong when $|r_{UV}|$ is close to one (Blatná, 2004).

2. Evaluation of bachelor degree theses by one FSE Board

To assess differences between evaluation of bachelor degree theses by their supervisors and opponents on the one side and a particular FSE Board on the other side Table 4 shows numerical evaluations of the theses by their supervisors and opponents (columns 2 and 3), with the mean value of columns 2 and 3 in column 4 (Mean). The Mean is used to express the theses evaluation by a single numerical value. Column 5 shows evaluation of defence of

Table 4 Table of Mean and Defence student results assessed by one Board.

Name	Supervisor	Opponent	Mean	Defence	*y*
Student1	1.5	1.0	1.25	1.50	−0.25
Student2	1.5	1.0	1.25	1.50	−0.25
Student3	1.5	1.0	1.25	1.50	−0.25
Student4	2.0	2.0	2.00	1.50	0.50
Student5	1.5	1.5	1.50	1.50	0.00
Student6	1.0	1.0	1.00	1.00	0.00
Student7	1.5	2.0	1.75	2.50	−0.75
Student8	1.5	1.0	1.25	1.50	−0.25
Student9	1.5	1.0	1.25	1.50	−0.25
Student10	2.0	1.0	1.50	1.50	0.00

Source: Final State Examinations Faculty of Business and Management, 2011.

the same theses by the Board (Defence). (It should be noted that Table 4 consists of student result data from Table 1 expressed in numbers.)

The last column of Table 4 shows values y of the random quantity *Y*, expressing the difference between the numerical values of the Mean and the Defence columns, *i.e.* Y = Mean – Defence.

The values may be interpreted as follows: When $y>0$, the Board evaluated the bachelor thesis less strictly than the supervisor and the opponent. When $y<0$, the Board evaluated the bachelor thesis more strictly than the supervisor and the opponent. When $y=0$, the Board evaluated the bachelor thesis identically with the supervisor and the opponent.

2.1 Bachelor degree theses evaluation with correlation coefficient

Correlation coefficient was used for assessment of the correlation between evaluation of student bachelor degree theses by their supervisors and opponents (expressed as Mean), and by the FSE Board (expressed as Defence).

Marking this correlation coefficient $r(Pr, Ob)$, then its value can be calculated by the formula (2) using values from Table 4:

$$r(Pr, Ob) = 0.564.$$

Finding 2.1: The value of this correlation coefficient shows approximately average correlation between the Mean and the Defence, *i.e.* for this FSE Board the mean evaluation of bachelor degree theses by their supervisors and opponents and the evaluation of the bachelor degree theses defence by the FSE Board show approximately average dependence on each other.

2.2 Bachelor degree theses evaluation with selective mean

To assess the value of the difference between evaluation of student bachelor degree theses by their supervisors and opponents and by the FSE Board, expressed by the random quantity *Y*, first the selective mean and the selective spread of this quantity had to be calculated from the values shown in Table 4. Thus:

$$\overline{y} \doteq -0.150;\ s_y^2 \doteq 0.100.$$

Finding 2.2: The value can be interpreted as the difference between evaluations of all bachelor degree theses assessed by this Board by their respective supervisors and opponents and evaluations of the same bachelor theses by the FSE Board. As this value is negative, it can be interpreted as follows: This Board assessed bachelor degree theses of all students in the group more strictly on average than the respective supervisors and opponents of the theses.

3. Evaluations of student knowledge by one FSE Board

This chapter analyses the correlations between student results achieved in the course of their studies, expressed by their Weighted Averages, and evaluation of knowledge of these students by a selected FSE Board in the Debate.

To assess the difference between evaluation of student knowledge in the course of their studies expressed under Weighted Average (*WA*), and evaluation of student performance in the Debate in front of the FSE Board expressed under Debate the numerical evaluation of the students in the selected ground is shown in Table 5. Weighted Average (*WA*) is shown in the second column of the table while the value of Debate in the third column. (It should be noted that Table 5 consists of student result data from Table 1 expressed in numbers.)

In the last column of Table 5 numbers x represent the values of the random quantity X, expressing the

Table 5. Table of Weighted Averages of student study results and the results of their evaluations by one Board in the Debate.

Name	*WA*	Debate	*x*
Student1	2.11	1.5	0.61
Student2	1.76	3.0	−1.24
Student3	1.60	2.0	−0.40
Student4	2.21	2.5	−0.29
Student5	2.13	2.0	0.13
Student6	1.81	2.0	−0.19
Student7	1.95	2.0	−0.05
Student8	1.41	1.5	−0.09
Student9	1.81	2.0	−0.19
Student10	1.94	2.0	−0.06

Source: Final State Examinations Faculty of Business and Management, 2011.

difference between the values of the Weighted Average and the Debate, *i.e.* X=*WA*–Debate. The values of x may be interpreted as follows: When $x>0$, the Board evaluated student knowledge in the Debate less strictly than the Weighted Average. When $x<0$, the Board evaluated student knowledge in the Debate more strictly than the Weighted Average. When $x=0$, the Board evaluated student knowledge in the Debate identically with the Weighted Average.

3.1 Evaluation of Student Knowledge with Correlation Coefficient

Correlation coefficient was used for assessment of the correlation between Weighted Averages of the students and evaluation of their knowledge by the Board in the Debate. Marking this correlation coefficient $r(WA; Ro)$, then its value can be calculated by the formula (2)

$$r(WA, Ro) = 0.172.$$

Finding 3.1: The value of this correlation coefficient shows weak correlation between the quantities Weighted Average and Debate, *i.e.* for this FSE Board knowledge of all students as evaluated in the course of their studies by the Weighted Average and evaluation of this knowledge by the Board in the Debate show little dependence on each other.

3.2 Student knowledge evaluation with selective mean

To assess the value of the difference between evaluation of student knowledge in the course of their studies with the Weighted Average and evaluation of the same knowledge by the Board in the Debate the values from Table 5 were used for calculation of the selective mean and the selective spread of the random quantity *X*. Thus:

$$\bar{x} \doteq -0.177; \quad s_x^2 \doteq 0.216.$$

Finding 3.2: The value can be interpreted as follows: As this value is negative, this Board assessed knowledge of all students in the Debate more strictly on average than as shown by their Weighted Average of overall study results during their course of study.

Then we assessed whether the value of this selective mean was statistically significantly different from zero, for if the values of the Weighted Average on the one side and evaluations of student knowledge by the Board in the Debate were the same then this value should equal to zero.

The assessment was based on the test with mean value of normal distribution performed as follows (Hátle, 1974).

- The zero hypothesis H_0: $\mu=0$, where μ is the mean value of the random quantity *X*, says that the values of the Weighted Average and knowledge evaluation by the Board in the Debate are approximately the same.
- The alternative hypothesis H_1: $\mu\neq0$ says that the values of the Weighted Average and knowledge evaluation by the Board in the Debate differ on average.
- If $\mu_0=0$ then the value of the test criterion will be $t=-1.204$.
- For $\alpha=0.05$ and $n=10$ the critical area is the interval (–2.262; 2.262).
- As the value of the test criterion was not within this interval, we can consider the difference between the value = –0.177 and zero as statistically insignificant.

Finding 3.3: In the student group assessed by the selected FSE Board the evaluations of student knowledge by the Board in the Debate and the student knowledge as assessed in the course of their studies and expressed by the Weighted Average are not statistically significantly different.

4. Evaluation of results for all FSE Boards in MI

This chapter will analyse differences in student evaluation before and after the final state examination for all FSE Boards in MI. Table 6 shows results of the individual Board evaluations of students in the course of the Final Bachelor Degree State Examination in MI in the academic year 2010/11. (It should be noted that the results of the selected FSE Board analysed in chapters 3 and 4 are shown in row 14).

In the leftmost column of the table the individual Boards are marked with numbers. In the other columns numerical values of the calculated characteristics for the respective Board are included.

- The second column shows correlation coefficients $r(WA, Ro)$.
- The third column shows selective mean values of $\overline{x} \cdot S$.
- The column entitled St.sign. (Statistical significance) shows whether the selective means $\overline{x}$ are statistically significantly different from zero. Where this column states "Yes" (statistically significant difference exists)/"No" (statistically significant difference does not exist), then for the respective Board the selective mean is/is not statistically significantly different from zero. (The individual steps of this test were described in Chapter 3).
- The fifth column shows correlation coefficients $r(Pr, Ob)$.
- The sixth and seventh columns shows selective mean values and selective spreads of the quantity Y.

4.1 Analysis of Weighted Average and Debate

This chapter will analyse the correlation between results of students of MI in the course of their studies characterised with the Weighted Average (WA) and evaluation of their knowledge in the Debate (Debate) for all FSE Boards of the MI study group.

4.1.1 Analysis of correlation coefficients r(WA, Ro)

It may be assumed that the results of students in the course of their studies characterised with the Weighted Average should not be significantly different from evaluations of their knowledge by the Board in the Debate. This should be shown by the correlation coefficients (WA, Ro) in the second column of the table for the individual FSE Boards which should be close to one.

Finding 4.1: Most of the tabulated values of correlation coefficients $r(WA, Ro)$ meet this assumption. However, there are Boards whose correlation coefficient is close to zero (Board 2) or even negative (Board 12). These anomalies in the correlation coefficients can be explained by the fact that some students with high Weighted Average of study results were unable to show their knowledge in front of the

Table 6. Table of results for individual FSE Boards.

Board	$r(WA, Ro)$	$\overline{x}$	St. sign.	$r(Pr, Ob)$	$\overline{y}$	s_y^2
1	0.560	0.231	No	0.638	0.075	0.098
2	0.020	−1.340	Yes	0.840	−0.278	0.069
3	0.733	0.231	Yes	0.771	0.050	0.067
4	0.728	−0.793	Yes	0.542	−0.525	0.076
5	0.162	−0.423	Yes	0.740	−0.417	0.219
6	0.597	−0.117	No	0.766	0.075	0.042
7	0.574	−0.194	No	0.403	−0.575	0.515
8	0.583	0.131	No	0.000	−0.375	0.411
9	0.540	−0.154	No	−0.556	−0.875	0.357
10	0.726	−0.054	No	0.832	0.028	0.069
11	0.472	−0.717	No	0.511	−0.472	0.601
12	−0.203	−0.020	No	0.750	−0.175	0.056
13	0.764	−0.382	No	0.872	0.111	0.127
14	0.172	−0.177	No	0.564	−0.150	0.100

Source: Final State Examinations Faculty of Business and Management, 2011.

Board at the Final State Examination and were classified with a low mark, and vice versa – knowledge of other students with low Weighted Average was assessed as good by the Board.

Excluding the values of correlations coefficients for Boards 2 and 12 the mean value of all the resulting coefficients would equal 0.551, which means slightly above-average correlations between student Weighted Averages and their evaluations by the Boards in the Debate for all remaining Boards.

4.1.2 Analysis of selective means $\bar{x}$

To assess how all FSE Boards assessed MI student knowledge in the Debate it is necessary to specify empirical characteristics of the random quantity $\bar{X}$, representing the mean value of random quantity X, *i.e.* selective mean $\bar{\bar{x}}$ and selective spread $s_{\bar{x}}^2$. Thus:

$$\bar{\bar{x}} = -0.270;\ s_{\bar{x}}^2 = 0.1906\,.$$

Finding 4.2: As the value of $\bar{\bar{x}} = -0.270$ is negative, it can be concluded that all FSE Boards in the MI group assessed student knowledge in the Debate more strictly on average than the same knowledge was evaluated in the course of the students' studies as expressed by the Weighted Average. In 10 of the Boards, *i.e.* in 71.4 %, this difference was statistically insignificant, while in 4 Boards, *i.e.* in 28.6 %, the difference showed statistical significance.

To find out the level of statistically significance of this negative evaluation we used the test with the mean value of normal distribution (Hátle, 1974). The test was performed as follows.

- The zero hypothesis H_0: $\mu \geq \mu_0$, where μ is the mean value of the random quantity , says that all MI Boards evaluated student knowledge in the Debate identically or higher on average than the overall study results of the students expressed by the Weighted Averages.
- The alternative hypothesis H_1: $\mu < \mu_0$ says that the MI FSE Boards evaluated student knowledge in the Debate more strictly on average than the overall study results of the students expressed by the Weighted Averages.
- If μ_0=0, then the value of the test criterion will be t=–2.314.
- For α=0,05 and n=14 the critical area is the interval (–∞; –1.771).
- As the value of the test criterion was within this interval, we can consider the difference between the selective mean = –0.270 and zero as statistically significant.

Finding 4.3: For all FSE Boards in the MI group evaluation of student knowledge in the Debate and by the Weighted Averages was statistically significantly different. Therefore all FSE Boards evaluated student knowledge more strictly than was the student knowledge evaluation expressed by the Weighted Averages.

4.2 Analysis of bachelor degree theses evaluation

This chapter will analyse the correlation between evaluation of bachelor degree theses of the students by the supervisors and opponents and evaluation of the bachelor degree theses defence by the FSE Boards in MI group (Pecáková, 2011; Hendl, 2008; Moravová, 1998; Punch, 2008; Hillebrandt, 1968; Čermák, 1980).

4.2.1 Analysis of Correlation Coefficients r(Pr, Ob)

It may be assumed that the evaluation of bachelor degree theses of students by their supervisors and opponents should not be significantly different from evaluations of their defence by the Board in the Debate. This should be shown by the correlation coefficients (*Pr*, *Ob*) in the fifth column of the table for the individual FSE Boards which should be close to one.

Finding 4.4: Most of the tabulated values of correlation coefficients *r*(*Pr*, *Ob*) meet this assumption. However, there are Boards whose correlation coefficient is close to zero or even negative (Boards 8 and 9). These anomalies in the correlation coefficients can be explained by the fact that some bachelor theses were evaluated by their supervisors and opponents as good while the Board assessed the defence of the theses as poor and vice versa – some bachelor theses evaluated by their supervisors and opponents as poor were well assessed by the Board.

Excluding the values of correlations coefficients for Boards 8 and 9 the mean value of all the resulting coefficients would equal 0.686, which means rather strong average correlation between evaluations of student bachelor degree theses by their supervisors and opponents and evaluations of their defences by the Boards.

4.2.2 Analysis of Selective Means

To assess how all FSE Boards assessed MI student bachelor degree theses defences it is necessary to specify empirical characteristics of the random quantity , representing the mean value of random quantity *Y*, *i.e.* selective mean and selective spread. Thus:

$$\bar{\bar{y}} = -0.250;\ s_{\bar{y}}^2 = 0.0915\,.$$

Finding 4.5: As the value of = –0.250 is negative, it can be concluded that all FSE Boards in the MI

group assessed defences of student bachelor degree theses more strictly on average than the same bachelor degree theses were evaluated by their respective supervisors and opponents. In 8 of the Boards, *i.e.* in 57.1 %, this difference was statistically insignificant, while in 6 Boards, *i.e.* in 42.9 %, the difference showed statistical significance.

To find out the level of statistically significance of this negative evaluation we used the test with the mean value of normal distribution (Hátle, 1974). The test was performed as follows.

- The zero hypothesis $H_{0:}\ \mu \geq \mu_0$, where μ is the mean value of the random quantity , says that all MI Boards evaluated student bachelor degree theses defence identically or higher on average than the same bachelor degree theses were evaluated by their respective supervisors and opponents.
- The alternative hypothesis H_1: $\mu < \mu_0$ says that the MI FSE Boards evaluated student bachelor degree theses defence more strictly on average than the same bachelor degree theses were evaluated by their respective supervisors and opponents.
- If $\mu_0=0$, then the value of the test criterion will be $t=-3.092$.
- For $\alpha=0.05$ and $n=14$ the critical area is the interval $(-\infty; -1.771)$.
- As the value of the test criterion was within this interval, we can consider the difference between the selective mean = –0.250 and zero as statistically significant.

Finding 4.6: For all FSE Boards in the MI group evaluation of student bachelor degree theses defence by the Boards and evaluation of the theses by their respective supervisors and opponents was statistically significantly different. Therefore all FSE Boards evaluated bachelor degree theses of the students more strictly than their supervisors and opponents.

Conclusion

The results of chapter 4 show the following:

Nearly all FSE Boards evaluated defences of student bachelor degree theses in MI subject more strictly than these theses were evaluated by their supervisors and opponents.

Nearly all FSE Boards evaluated student knowledge in the Debate more strictly than the same knowledge was evaluated in the course of the students' studies as is expressed by the Weighted Averages.

If we accept the fact that the Boards are appointed at random and therefore cannot be interested in "harming" the students then what follows from the above is:

- The not very favourable results of evaluations of the students' bachelor degree theses and their defences by the Boards can be explained either by too "mild" evaluation of the bachelor degree theses by their supervisors and opponents or by poorly prepared defences of these theses. (It needs to be noted here that the Boards do not assess the bachelor degree theses as such but their defences. And also that the members of the Boards read the bachelor degree theses beforehand and as they evaluate more than one thesis they can compare. And finally that a well written bachelor degree thesis can be well defended while the same is not true about a poorly written thesis.)
- The not very favourable results of evaluations of the students' knowledge by the FSE Boards in the Debate can be explained either by poor knowledge of the students or by their poor preparation for the requirements of the Final State Examination.

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