AP® Statistics
2002 Sample Student Responses
Form B

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(a) Do the data provide evidence that the mean number of lab classes taken by biology majors in September 2000 was different from the mean number of lab classes taken in 1990 ? Perform an appropriate statistical test using $\alpha = 0.10$ to answer this question.

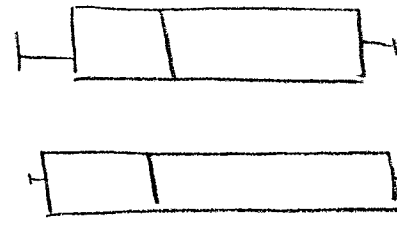
$H_0: \mu_1 - \mu_2 = 0$

$H_a: \mu_1 - \mu_2 \neq 0$

where μ_1 = # of lab classes taken in 1990

μ_2 = # of lab classes taken in 2000

$\bar{x}_1 = 1.83$
$n_1 = 200$
$s_1 = 1.29$



There is some skewness in the data, but there are no outliers, so I will go ahead and use the t-distribution anyway.

$\bar{x}_2 = 1.93$
$n_2 = 200$
$s_2 = 1.37$

$$T = \frac{(1.83 - 1.93) - 0}{\sqrt{\frac{1.29^2}{200} + \frac{1.37^2}{200}}} = -.7515$$

$2P(T \leq -.7515) = .4528$

There is not significant statistical evidence, with a p-value of .4528, to conclude that the mean # of lab classes in 1990 is different from the # in 2000. We fail to reject H_0.

(b) Does the test in (a) address the question of whether the distribution of number of lab classes was different in 2000 than it was in 1990 ? If so, explain your reasoning. If not, carry out an appropriate statistical test using $\alpha = 0.10$ to answer this question.

H_0: distribution was the same in 1990 and 2000
H_a: distribution was not the same in 1990 and 2000

# lab classes	0	1	2	3	4	5
1990	28 (24)	62 (67)	58 (59)	28 (19)	16 (21)	8 (10)
2000	20 (24)	72 (67)	60 (59)	10 (19)	26 (21)	12 (10)

Expected values in parentheses
all expected values ≥ 5, so χ^2 test is appropriate

$\chi^2 = \sum \frac{(O-E)^2}{E} = 13.82$ $\quad df = 5$

$P(\chi^2 \geq 13.82) = .0168$

There is significant statistical evidence, with a p-value of .0168, to indicate that the distribution of # of lab classes has changed from 1990 to 2000.
We reject H_0.

3 of 3

(c) Use the results of your analyses in (a) and (b) to write a few sentences that summarize how the distribution of the number of lab classes did or did not differ. Use appropriate graphs to help communicate your message. This summary should be understandable to someone who has not studied statistics.

While the mean # of lab classes did not differ by much, the distribution changed significantly. There was a general upward shift, as 2000 saw more students taking 4 or 5 classes and fewer taking 0 lab classes than in 1990

END OF EXAMINATION

THE FOLLOWING INSTRUCTIONS APPLY TO THE BACK COVER OF THE SECTION II BOOKLET.

- **MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE BACK OF THE SECTION II BOOKLET.**
- **CHECK TO SEE THAT YOUR AP NUMBER APPEARS IN THE BOX(ES) ON THE BACK COVER.**
- **MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMINATIONS YOU HAVE TAKEN THIS YEAR.**

(a) Do the data provide evidence that the mean number of lab classes taken by biology majors in September 2000 was different from the mean number of lab classes taken in 1990 ? Perform an appropriate statistical test using $\alpha = 0.10$ to answer this question.

1) $H_0: \mu_1 = \mu_2$ $H_a: \mu_1 \neq \mu_2$
μ_1 is the mean number of lab classes taken by bio majors in Sept. 1990
μ_2 is the mean number of lab classes taken by bio majors in Sept. 2000.

2) Use 2-sample t-test
Requirements : both samples are SRS's
200 + 200 > 40 so a normal population isn't required

3) $\bar{x}_1 = 1.83$ $\bar{x}_2 = 1.93$
$s_1 = 1.29$ $s_2 = 1.37$
$n_1 = 200$ $n_2 = 200$

$$t = \frac{(1.83 - 1.93) - 0}{\sqrt{\frac{(1.29)^2}{200} + \frac{(1.37)^2}{200}}} = -.7515$$

4) p-value = $2 \cdot tcdf(-1000, -.751, 199) = .4532$ → Assuming H_0 is true, this is the probability of getting a difference in sample means this extreme

5) Fail to reject H_0 at the 10% level. The p-value shows that the difference in sample means isn't statistically significant & is probably due to chance.

(b) Does the test in (a) address the question of whether the distribution of number of lab classes was different in 2000 than it was in 1990 ? If so, explain your reasoning. If not, carry out an appropriate statistical test using $\alpha = 0.10$ to answer this question.

No, it only addresses the question of whether the mean number of lab classes was different.

1) H_0: The distribution of classes did not differ in 1990 & 2000 — the number of lab classes taken is independent of the year
H_a: The distribution of classes did differ in 1990 & in 2000 — the number of lab classes is not independent of the year.

2) Use χ^2-test
Requirements: Both samples are SRS's
All expected values > 5

3)

	# lab classes					
	0	1	2	3	4	5
# students in 1990	28	62	58	28	16	8
Expected #	24	67	59	19	21	10
# students in 2000	20	72	60	10	26	12
Expected #	24	67	59	19	21	10

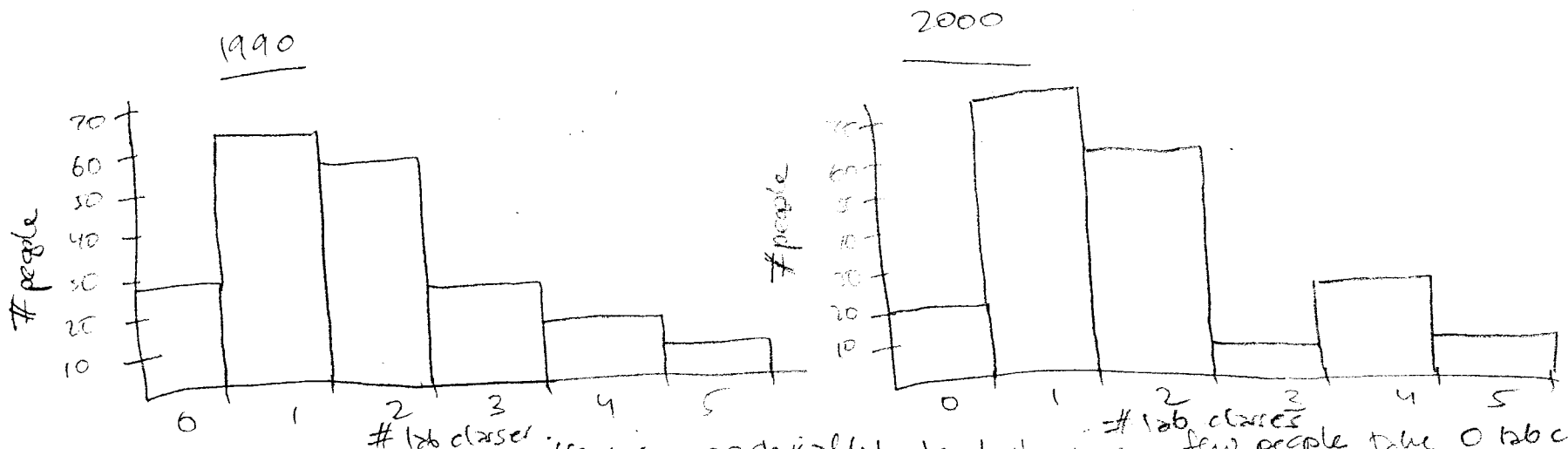
$\chi^2 = \sum \frac{(O-E)^2}{E} = 13.82$

4) P-value = χ^2-cdf (13.82, 10000, 5) = .0168 → Assuming H_0 is true, this is the probability of getting a difference in distributions this extreme.

5) Reject H_0 at the 10% level. The difference in the distributions is too great to be due to chance (according to the high P-value). The distributions are probably not independent.

(c) Use the results of your analyses in (a) and (b) to write a few sentences that summarize how the distribution of the number of lab classes did or did not differ. Use appropriate graphs to help communicate your message. This summary should be understandable to someone who has not studied statistics.

While the mean number of lab classes taken in 2000 doesn't significantly differ from the mean number taken in 1990 the distribution of the number of students who took certain number of classes differs in the 2 years.



We can see this difference graphically. In both years few people take 0 lab classes, most take 1, and after that, in general, fewer and fewer people take a greater number of lab classes. However, while in 1990 this change is gradual and smooth, in 2000 there is a surprisingly low number of people who took 3 lab classes. This changes the entire distribution — both its statistical meaning and its basic graphical appearance. Somewhere along the 10 years that elapsed, fewer people wanted to take 3 lab classes, & this change is so drastic that it's probably the one that damaged the entire distribution.

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