

Evaluating an Alternative CS1 for Students with Prior Programming Experience

Michael S. Kirkpatrick

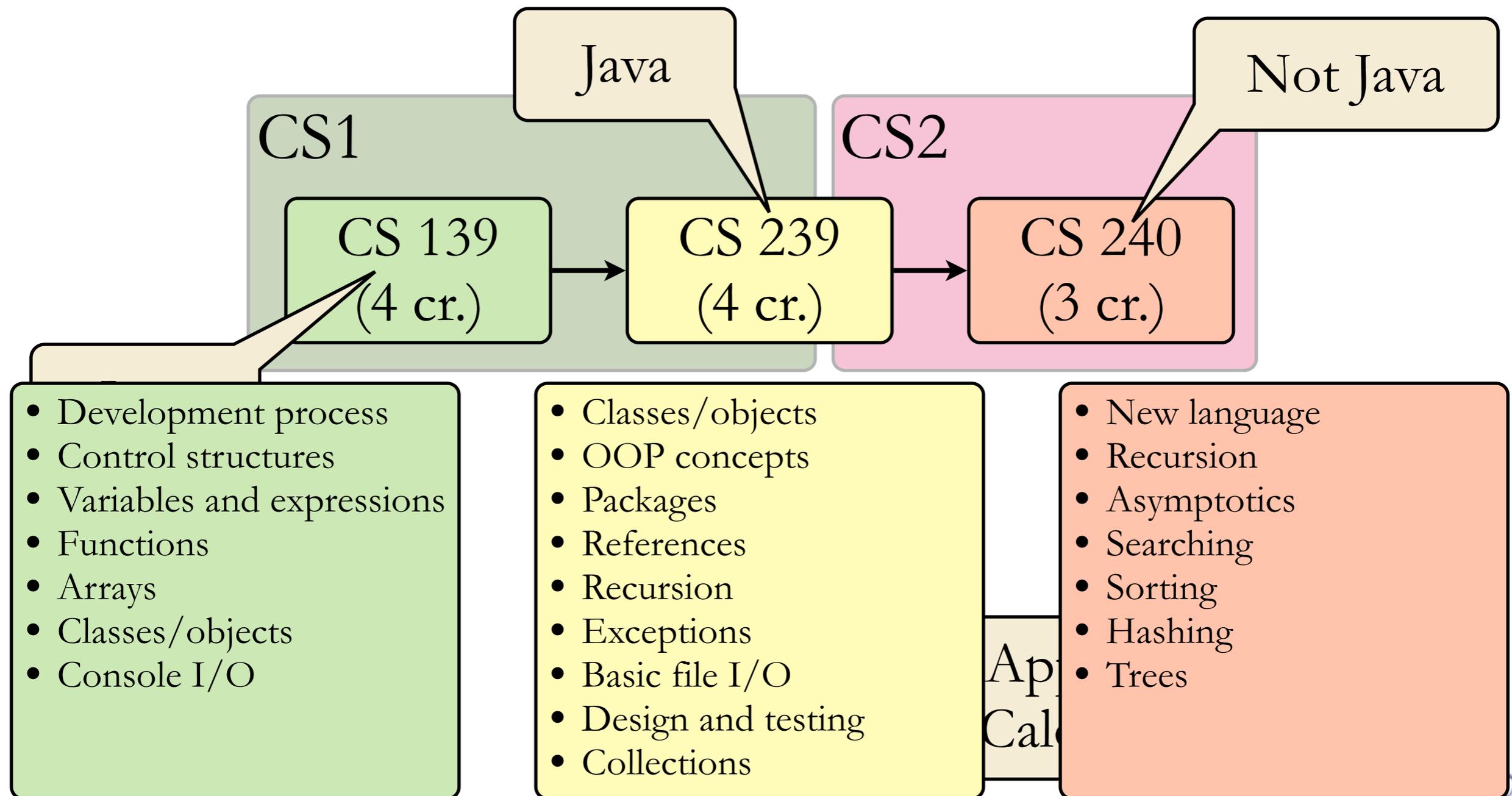
Chris Mayfield

SIGCSE Technical Symposium

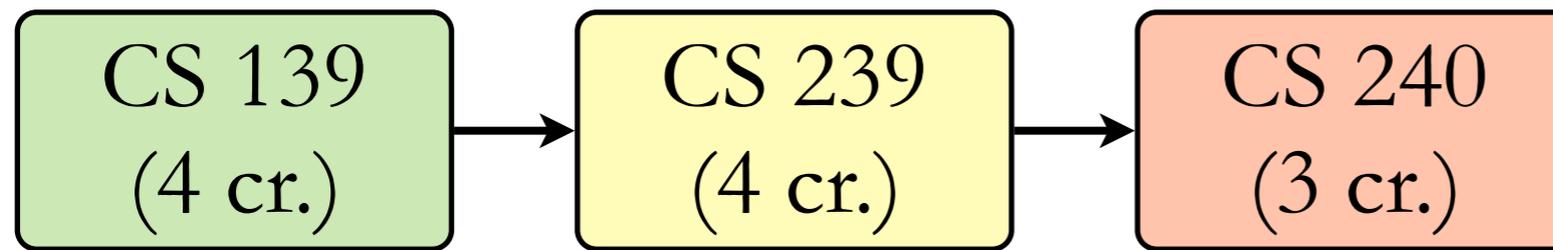
March 2017



JMU Introductory Sequence



JMU Introductory Sequence



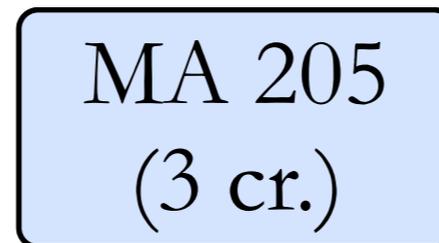
Goals and benefits

- No prior programming experience required
- Emphasis on problem-solving and algorithm design
- Maintain positive climate
- Small class sizes
- Exposure to two languages

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graph LR; A[CS 139  
(4 cr.)] --> B[CS 239  
(4 cr.)]; B --> C[CS 240  
(3 cr.)]
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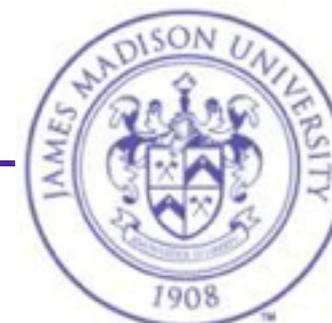
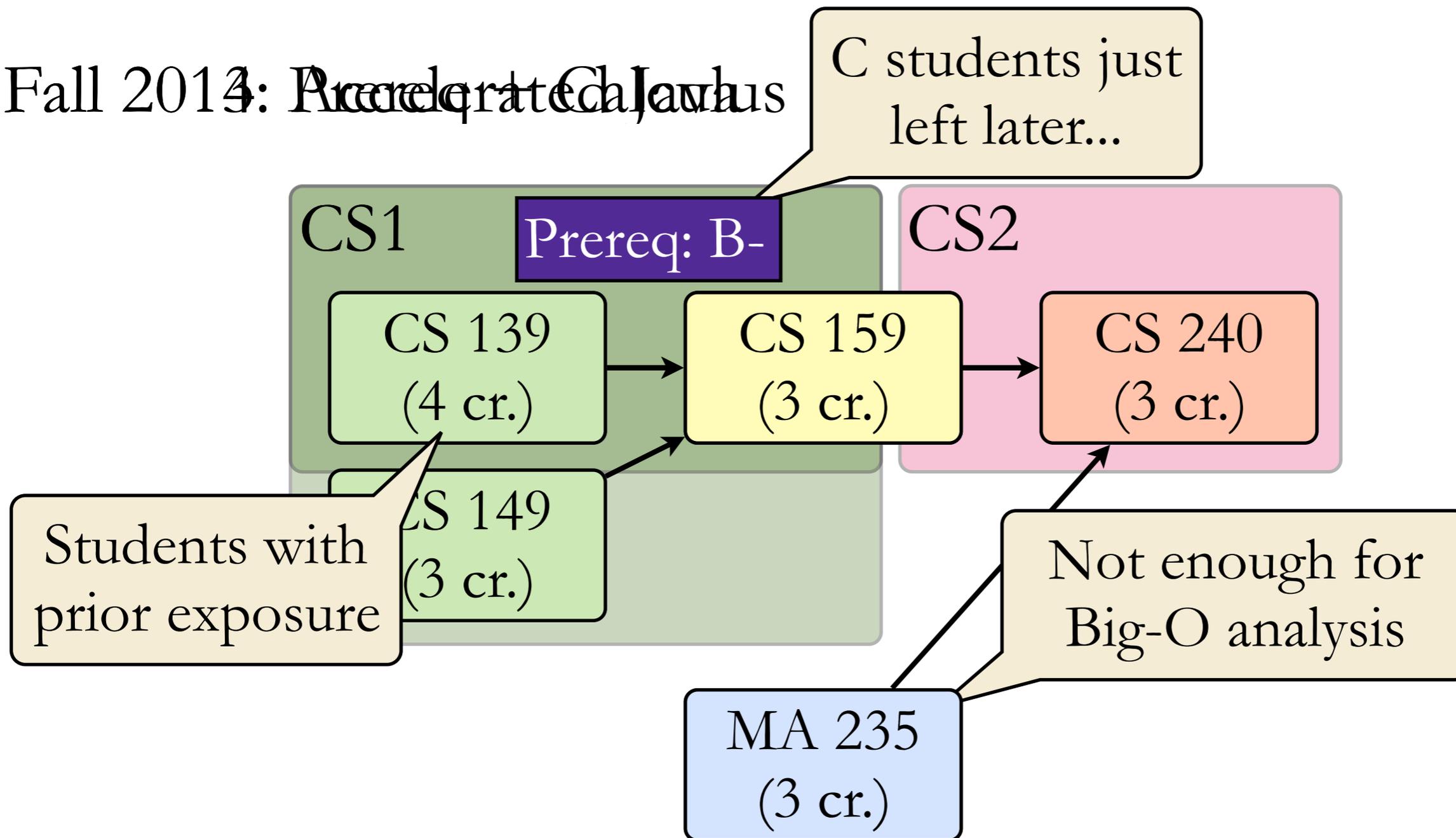
CS1

CS2



JMU Introductory Sequence

Fall 2014: Accelerated Ch. 1



Key (Research) Questions

Effects on retention

- Did either change affect retention into CS 159?
- Did either change affect retention beyond CS 159?

Effects on successful progression

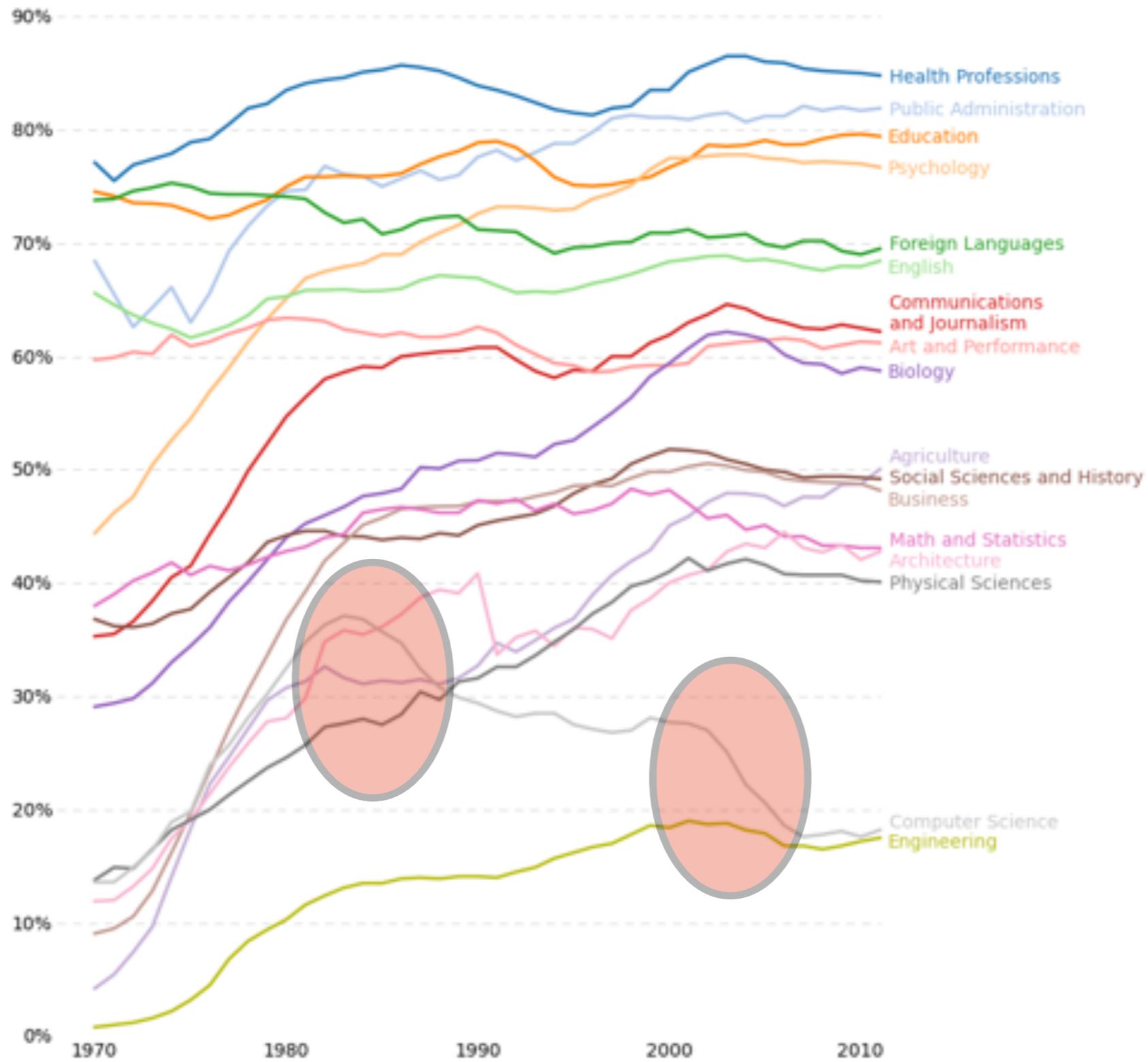
- How did they do in CS 240?

Effects on underrepresented groups

- Do overall effects extend to women and underrepresented minority students?



Percentage of Bachelor's degrees conferred to women in the U.S.A., by major (1970-2012)



Data source: nces.ed.gov/ipeds/data/digest/2013menu_tables.asp
 Author: Randy Olson (randalolson.com / [@randal_olson](https://twitter.com/randal_olson))
 Note: Some majors are missing because the historical data is not available for them



Research Hypotheses

CS 159 and CS 240 retention

- The split sections improve retention.
- The Calculus/B- change led to drop in retention.

CS 159 and CS 240 grades

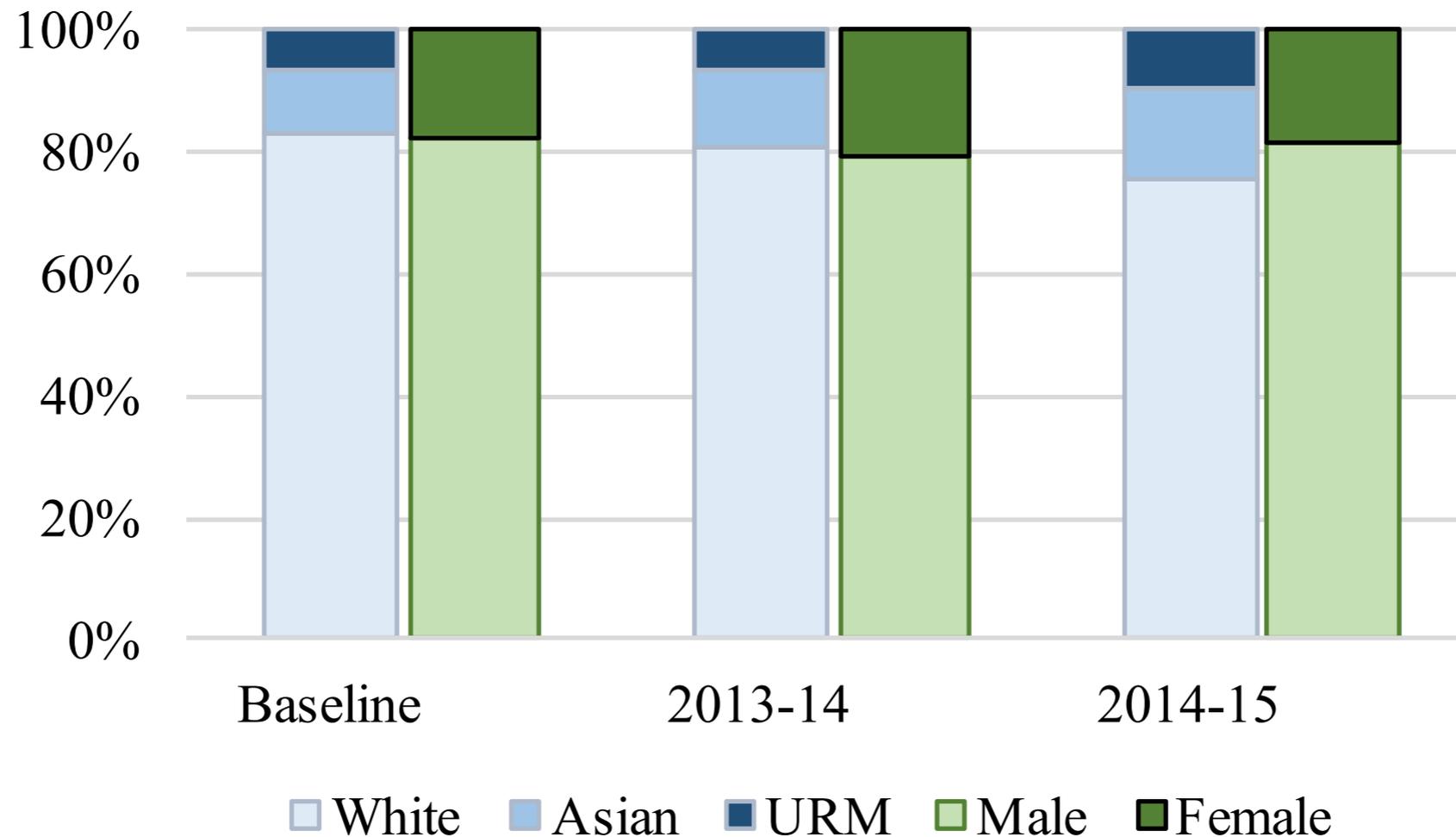
- CS 139/149 has no effect on CS 159 or CS 240 grades.
- Skip CS 139/149 with AP 4 yields difference in CS 159.
- AP 4 + CS 139/149 no difference in CS 159 or CS 240 relative to AP 5.

Effect on women and URM students

- Split sections improve women/URM retention.
- Calculus/B- had disproportionate effect on women/URM.



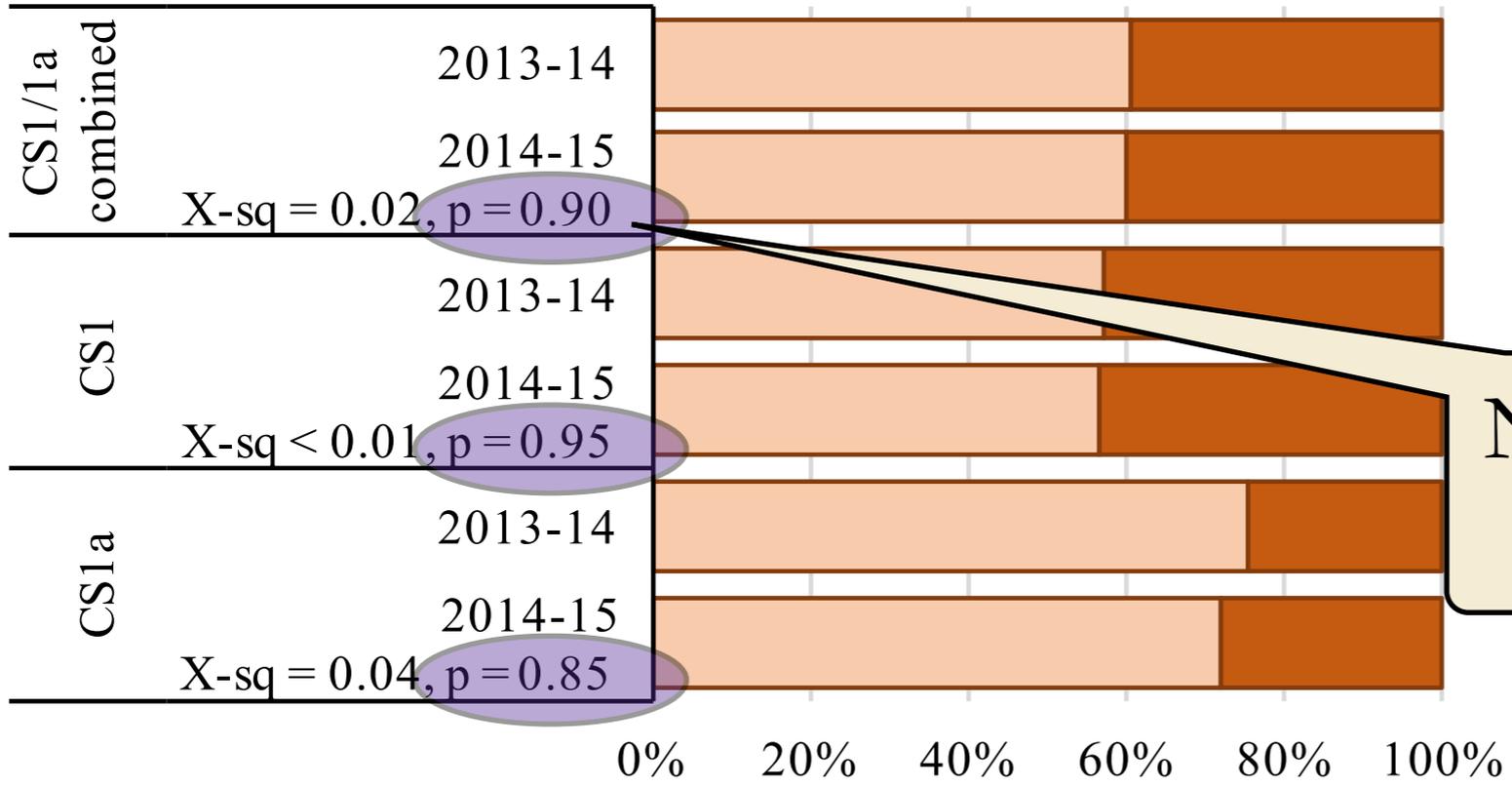
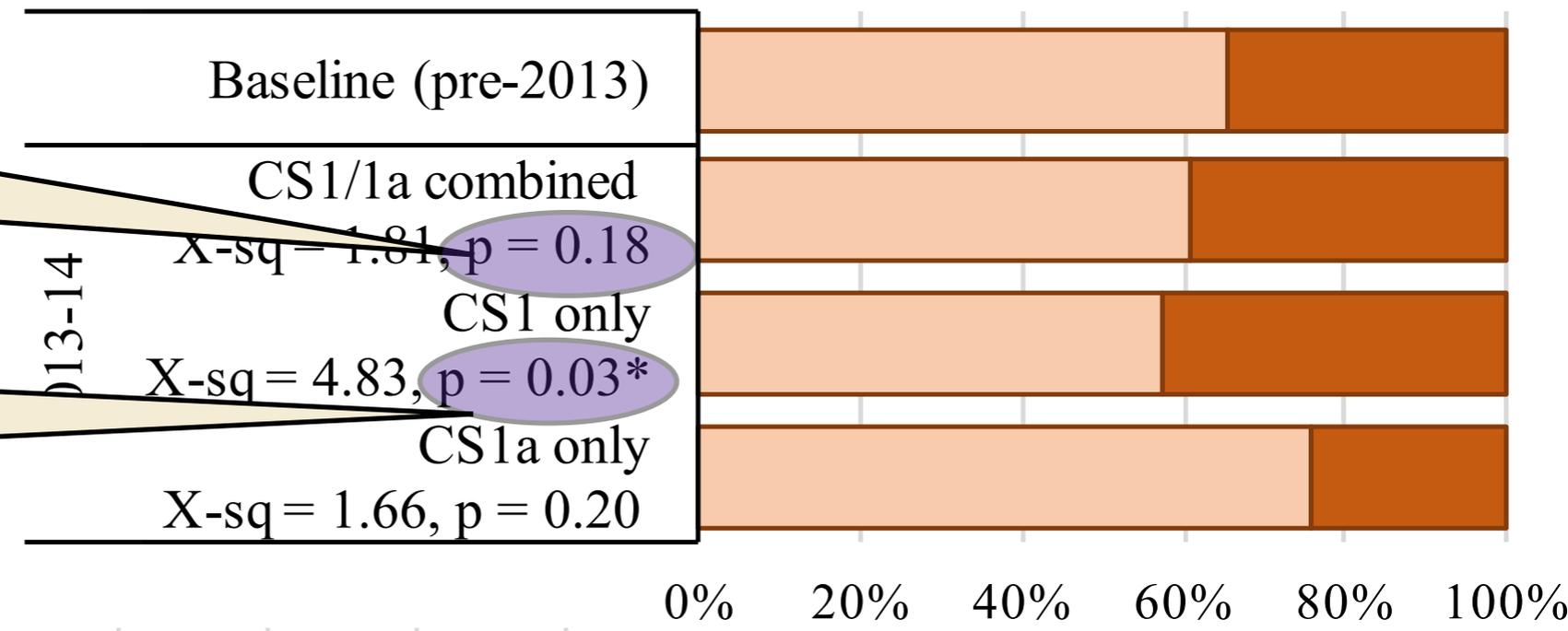
CS 139/149 Demographics



CS 139/149 → CS 159/239 Retention

No overall effect after splitting sections

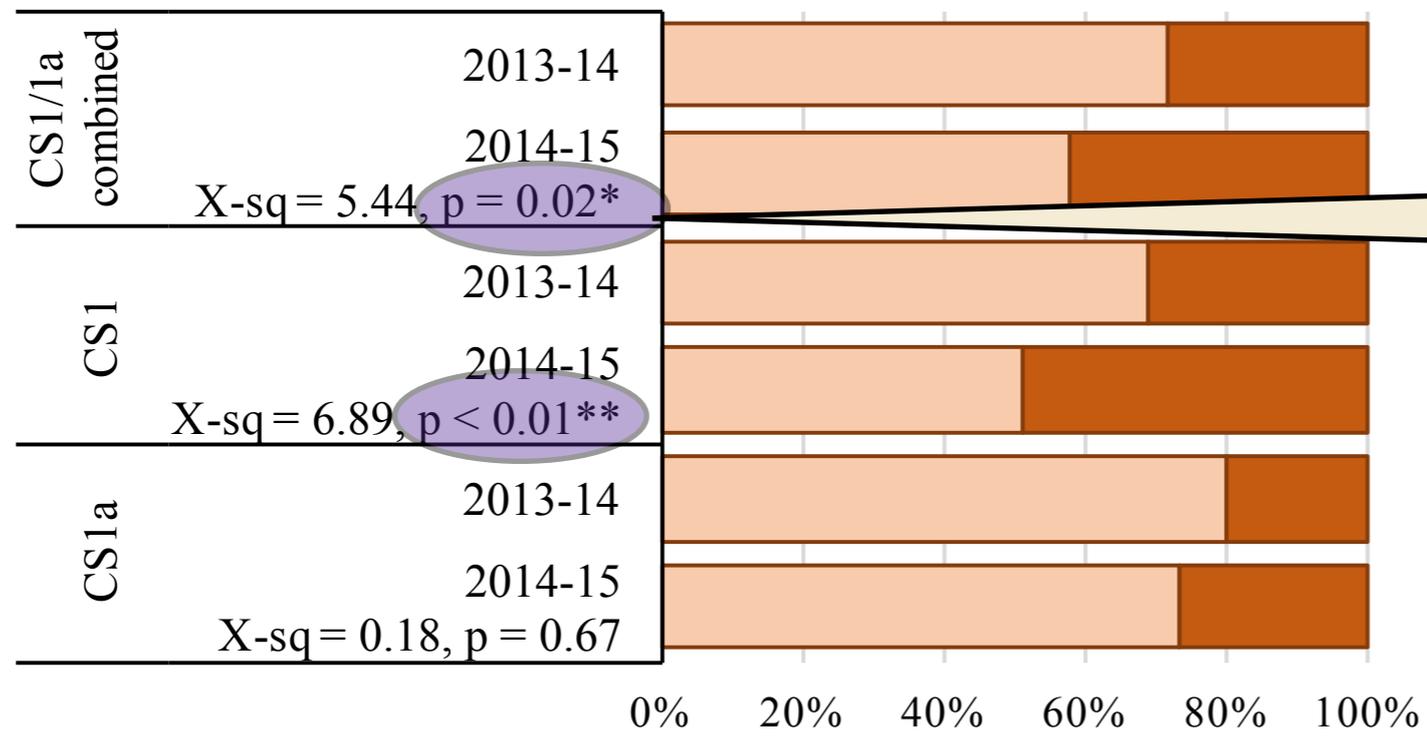
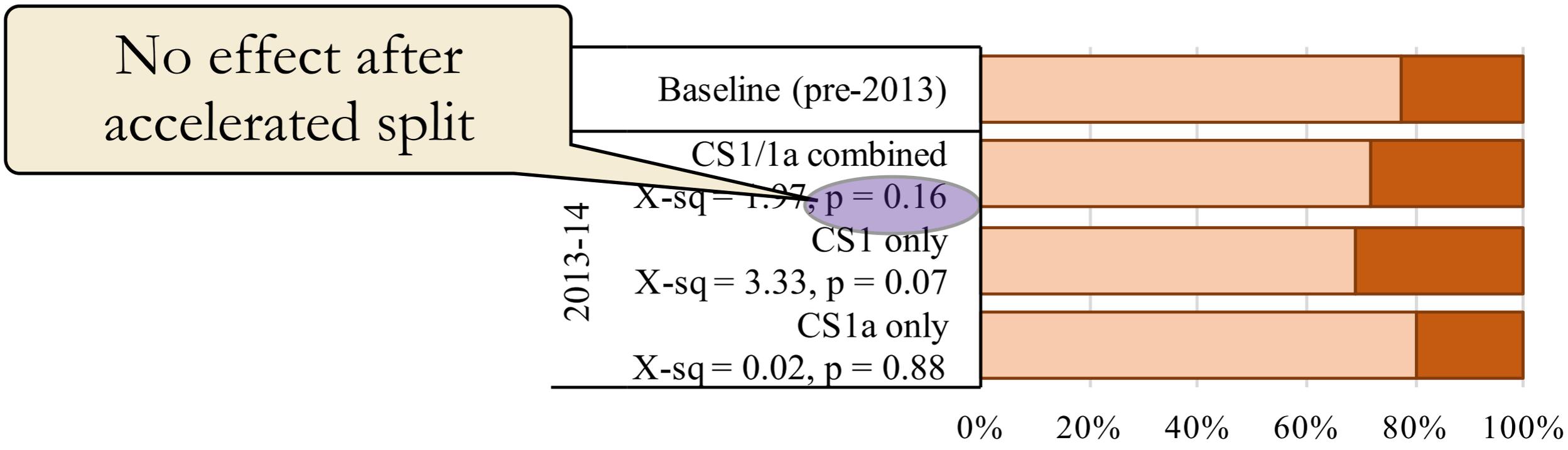
Difference between CS 139 and previous combined



No effect after adding B- prerequisite



CS 159 → 240 Retention



Significant difference after Calculus/B-, but...



Research Hypotheses

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- The Calculus/B- change led to drop in retention. ✓ / ✗

CS 159 and CS 240 grades

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How were their grades?

Linear regression on CS 159 grades

- Choice of CS 139 vs CS 149? Significant ($p < 0.05$)
- Grade in CS 139/149? Very significant ($p < 0.001$)
- # of attempts in CS 139/149? Very significant ($p < 0.01$)

CS1.5 Grade		Spearman's rank coefficient	
CS1.5 grade factor	Est.	ρ	p-value
(Intercept)	0.745	$\rho = 0.436$	$p = 0.0009$ **
CS1/1a Grade	0.319	$\rho = 0.492$	$p < 3e-16$ ***
CS1/1a Attempts	0.834	$\rho = -0.182$	$p = 0.002$ ***
CS1X Attempts	-0.600	$\rho = -0.224$	$p = 0.008$ **

Residual standard error: 0.917 on 270 degrees of freedom
 Multiple R-squared: 0.2633, Adjusted R-squared: 0.2552
 F-statistic: 32.17 on 3 and 270 DF, p-value: $< 2.2e-16$



How were their grades?

Linear regression on CS 240 grades

- Choice of CS 139 vs CS 149? **NOT** significant
- Grade in CS 159? Very significant ($p < 0.001$)
- # of attempts in CS 139/149? **NOT** significant

CS2 grade factor	Est.	SE	t value	Pr(> t)
CS1			$\rho = 0.052, p = 0.489$	
(Intercept)	1.187	0.234	5.079	$\leq 1e-06$ ***
CS1.5a Grade	0.512	0.075	6.788	$\leq 5e-11$ ***
CS1.5 Grade	0.512	0.075	6.788	$\leq 2e-10$ ***

Residual standard error: 0.723 on 177 degrees of freedom
 Multiple R-squared: 0.2066, Adjusted R-squared: 0.2021
 F-statistic: 46.08 on 1 and 177 DF, p-value: 1.651e-10



What about AP students?

Average grades in CS 159/240

- AP 4 who skipped CS 139/149 did worse in CS 159

Course	Mean Samples	Result
CS1.5/1.5a	AP 5, $\mu = 3.4$ AP 4 (skip), $\mu = 2.8$	$t = 2.4, df = 56.2$ $p = 0.02^*$
CS1.5/1.5a	AP 5, $\mu = 3.4$ AP 4 (no skip), $\mu = 3.0$	$t = 1.9, df = 53.9$ $p = 0.06$
CS1.5/1.5a	AP 4 (skip), $\mu = 2.8$ AP 4 (no skip), $\mu = 3.0$	$t = -0.7, df = 55.2$ $p = 0.47$
CS2	AP 5, $\mu = 2.7$ AP 4 (skip), $\mu = 2.2$	$t = 1.6, df = 44.6$ $p = 0.12$
CS2	AP 5, $\mu = 2.7$ AP 4 (no skip), $\mu = 2.7$	$t = 0.2, df = 39.0$ $p = 0.82$
CS2	AP 4 (skip), $\mu = 2.2$ AP 4 (no skip), $\mu = 2.7$	$t = -1.5, df = 42.2$ $p = 0.15$



Research Hypotheses

CS 159 and CS 240 retention

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- The Calculus/B- change led to drop in retention. ✓ / ✗

CS 159 and CS 240 grades ✗ / ✓

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- Skip CS 139/149 with AP 4 yields difference in CS 159. ✓
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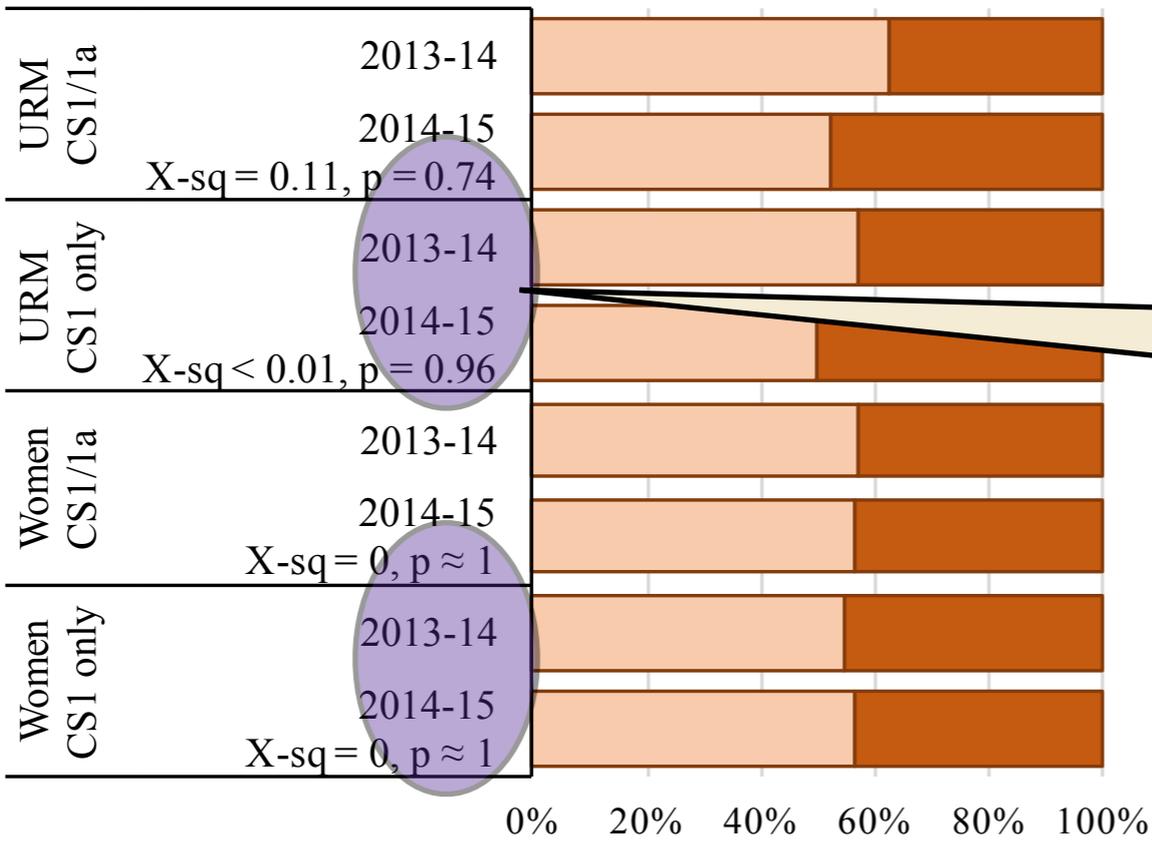
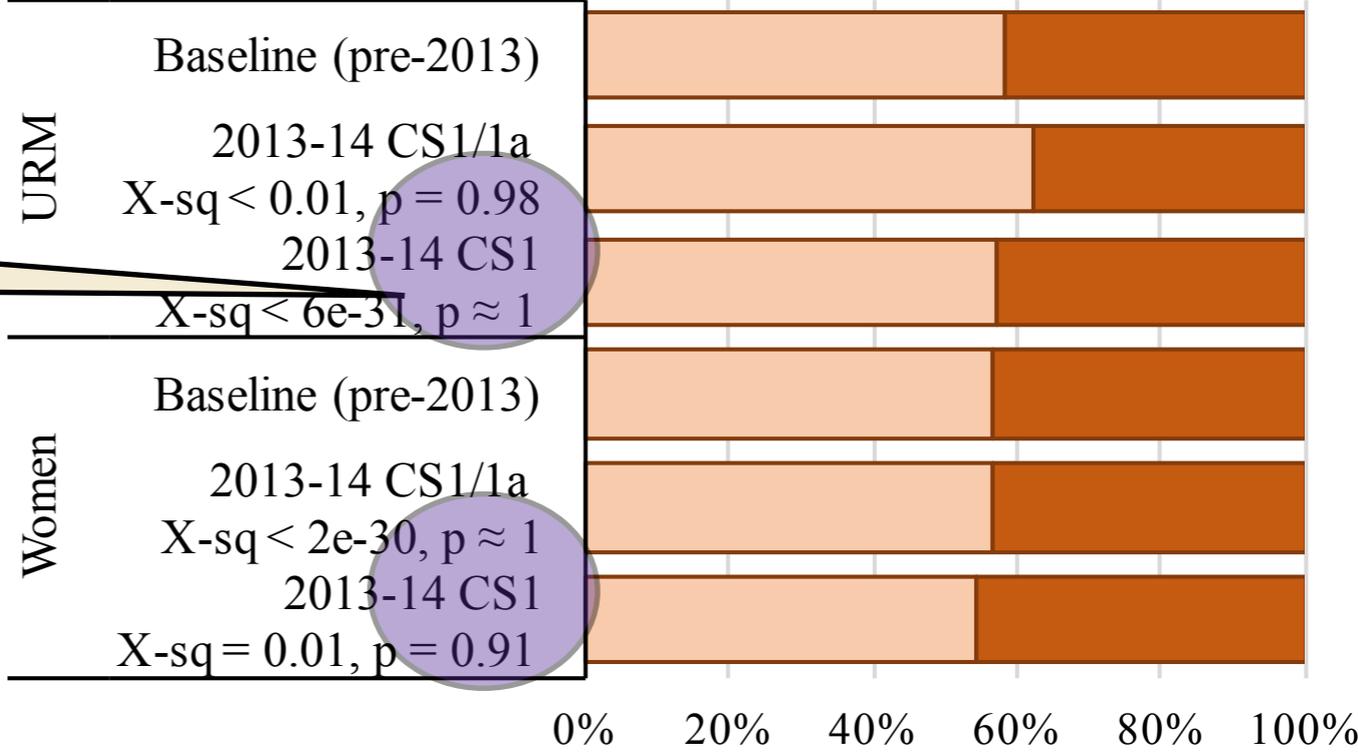
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CS 139/149 → CS 159/239 Retention

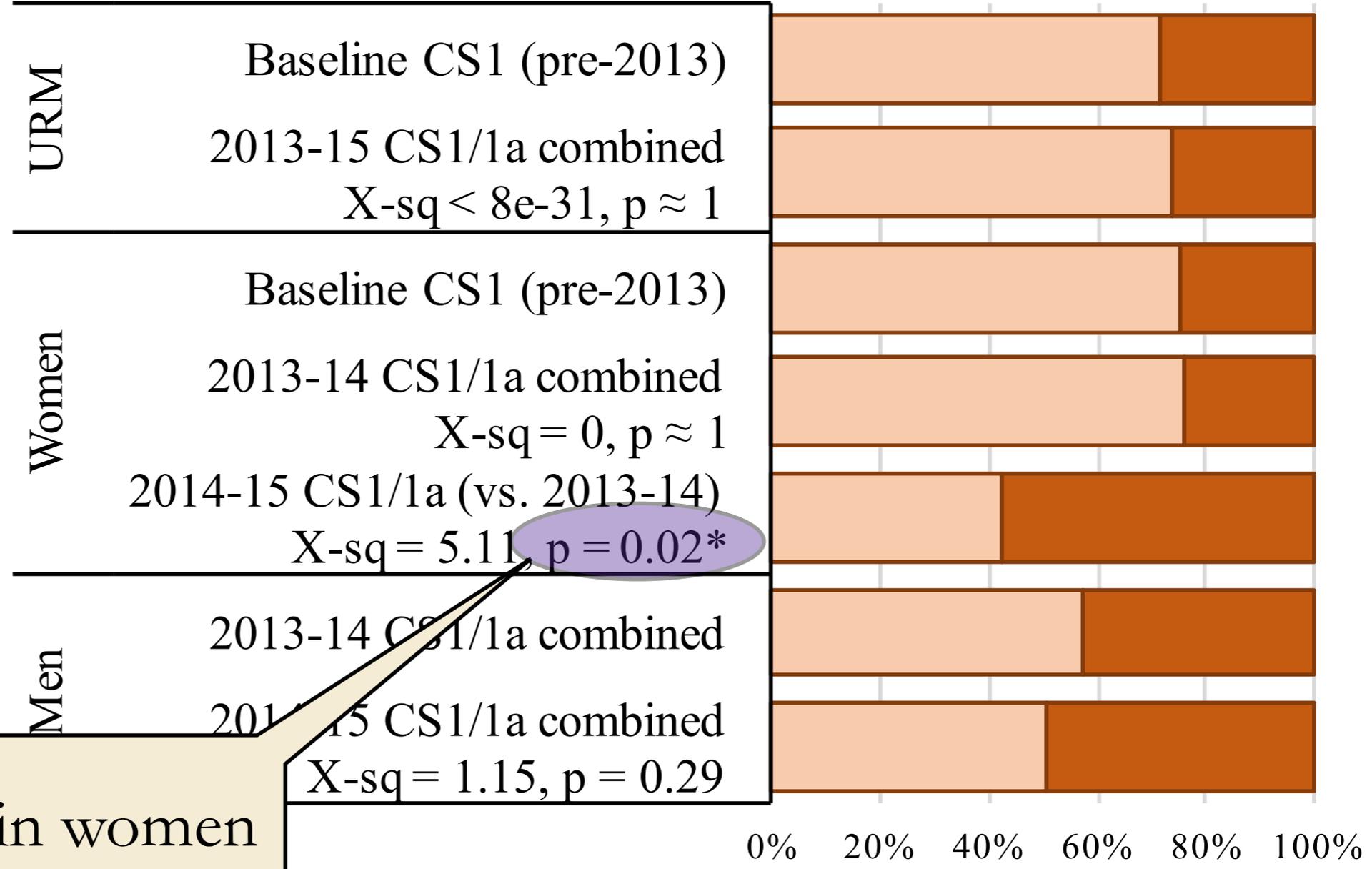
No effect after accelerated split



No effect after increasing to B-



CS 159 → CS 240 Retention



Significant drop in women retention after increasing Calculus requirement...



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? / ✗



Key Takeaways

Extended intro helps level playing field

- No difference by the end of CS2

Extended intro helps students with AP 4

- No difference by the end of CS2

Extended intro helps for fair enrollment mgmt

- No evidence of prior exposure bias



Thank you

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