A/B Testing Report on Online Course Promotions

Analytics, Hypothesis Testing, and Strategic Insights

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October 4, 2025

GitHub Repository: https://github.com/riku-d/Abtest1

Deployed Site: https://abtest-esy8.onrender.com

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1 System Description (Detailed)

This project implements a web-based A/B testing platform to evaluate two course-promotion strategies on an e-learning site. The system was designed to be minimal yet complete for A/B experimentation, collecting the specific events required for analysis:

- **Stack (implementation notes):** React frontend, Express backend, MongoDB (or any document store) for event logs and aggregated metrics. The app is deployed at `https://abtest-esy8.onrender.com`. Source code: `https://github.com/riku-d/Abtest1`.
- **Variants:**
  - **Variant A (Control):** Free course access; certificate available for a fee.
  - **Variant B (Treatment):** 50% discount on the course and certificate is free.
- **Events Tracked:** `exposure`, `view_details`, `know_more`, `enrollment (buy)`, session id, timestamp, variant id, course id, and rating metadata.
- **Analytics:** Dashboard computes exposures, clicks, enrollments, conversion rates (%), click-through rate (CTR), and variant share; charts show trends and comparison bars.
- **Randomization:** On first visit users were randomly assigned to Variant A or B (50/50 split by design) and persisted via a cookie/session id to prevent re-assignment.

Goal: Decide which promotion strategy yields higher conversions (enrollments) and extract practical recommendations for pricing/certificate policy.

2 Experimental Design and Metrics

2.1 Sample and Duration

- **Minimum requirement (project):** at least 40 users. Our test aggregated **110 exposures** and **30 enrollments** (see results).
- **Assignment:** Randomized assignment at user/session level between Variant A and Variant B.

2.2 Primary and Secondary Metrics (definitions)

Exposure: user visit which is eligible for assignment (counts once per session).

View Details: number of times users clicked to view course details.

Know More: clicks on additional course information.

CTR (here): View Details clicks / Exposures. (We report this metric as the primary engagement click.)

Enrollment (conversion): user completes the buy/enroll flow (counted as success).

Conversion Rate (CR): $\hat{p} = \dfrac{\text{Enrollments}}{\text{Exposures}}$ for the variant (expressed as a percentage).

2.3 Experimental Hypotheses

We test whether Variant A performs better than Variant B on conversions.

$$H_0 : p_A = p_B \qquad \text{(no difference)}$$

$$H_1 : p_A > p_B \qquad \text{(Variant A has higher conversion)}$$

A one-sided two-proportion Z-test is chosen because we are testing for a direction (A better than B). The same data can also be evaluated with a two-sided test if a non-directional conclusion is required.

3 Experimental Results (Summary)

3.1 Top-line numbers

- **Total Exposures:** 110
- **Total Enrollments:** 30
- **Overall Conversion Rate:** $30/110 = 27.27\%$
- **Course preference :** High-rating course dominated enrollments (25 of 30).

3.2 Variant-wise aggregated performance

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Variant	Exposures (n)	View Details	Enrollments (x)	Conversion Rate ($\hat{p} = x/n$)
A (Free + Cert fee)	58	18	20	$20/58 = 0.3448 = 34.48\%$
B (50% OFF + Free Cert)	52	15	10	$10/52 = 0.1923 = 19.23\%$

Table 1: Variant performance (engagement and conversion)

CTR (as defined):

$$\text{CTR}_A = \frac{18}{58} = 31.03\%, \quad \text{CTR}_B = \frac{15}{52} = 28.85\%.$$

3.3 Course-wise performance (rating influence)

Course	Rating	Price	Enrollments	Conversion Rate
Full Stack Career Accelerator	4.8	599	25	$25/55 = 45.45\%$
Web Dev Fundamentals	3.2	399	5	$5/55 = 9.09\%$

Table 2: Enrollments by course and rating. (Exposures by course assumed: 55 each; see note below.)

Note: the data shows 25 and 5 enrollments on the two courses; dividing by 55 exposures each gives the conversion rates above (55 + 55 = 110 total exposures).

4 Statistical Analysis: Two-Proportion Z-Test (Detailed)

We now perform the hypothesis test step-by-step using the variant-level counts from Table 1.

4.1 Observed proportions

$$n_A = 58, \quad x_A = 20, \quad \hat{p}_A = \frac{x_A}{n_A} = \frac{20}{58} \approx 0.3448275862 \ (34.48\%)$$

$$n_B = 52, \quad x_B = 10, \quad \hat{p}_B = \frac{x_B}{n_B} = \frac{10}{52} \approx 0.1923076923 \ (19.23\%)$$

4.2 Pooled proportion (used under H_0)

Under H_0 we assume the same population proportion, so:

$$\hat{p} = \frac{x_A + x_B}{n_A + n_B} = \frac{20 + 10}{58 + 52} = \frac{30}{110} = 0.2727272727$$

4.3 Standard error (pooled)

$$SE_{\text{pooled}} = \sqrt{\hat{p}(1-\hat{p})\left(\frac{1}{n_A} + \frac{1}{n_B}\right)}$$

Substitute numerically:

$$SE_{\text{pooled}} = \sqrt{0.2727272727 \times 0.7272727273 \times \left(\frac{1}{58} + \frac{1}{52}\right)} \approx 0.08505$$

4.4 Z-statistic

We compute the test statistic (difference in sample proportions divided by pooled SE):

$$Z = \frac{\hat{p}_A - \hat{p}_B}{SE_{\text{pooled}}} = \frac{0.3448275862 - 0.1923076923}{0.0850537781} \approx 1.7932$$

4.5 P-value (one-tailed)

Because H_1 is directional ($p_A > p_B$), the one-tailed p-value is:

$$p_{\text{one-tailed}} = P\left(Z > 1.7932\right) \approx 0.03647$$

Thus at $\alpha = 0.05$ (one-tailed) we have $p < 0.05$ and reject H_0 in favor of H_1.

4.6 Two-tailed perspective and confidence interval

For completeness we compute the two-tailed p-value:

$$p_{\text{two-tailed}} \approx 0.07294$$

and a 95% confidence interval (CI) for the difference in proportions using the *unpooled* standard error (appropriate for CI):

$$SE_{\text{diff}} = \sqrt{\frac{\hat{p}_A(1-\hat{p}_A)}{n_A} + \frac{\hat{p}_B(1-\hat{p}_B)}{n_B}} \approx 0.08296$$

$$\text{difference } = \hat{p}_A - \hat{p}_B \approx 0.15252$$

95% CI:

$$\hat{p}_A - \hat{p}_B \pm z_{0.975} \cdot SE_{\text{diff}} = 0.15252 \pm 1.95996 \times 0.08296$$

$$\Rightarrow \text{CI}_{95\%} \approx (-0.01008,\ 0.31512)$$

Interpretation:

- The one-tailed test (targeting whether A is better) yields $p \approx 0.0365 < 0.05$, so Variant A is significantly better than Variant B at the 5% one-sided level.
- The two-tailed test gives $p \approx 0.073 > 0.05$, and the 95% CI marginally includes 0. This means that if you require a two-sided test, results are *not* significant at the 5% level.

- Practical takeaway: There is evidence that Variant A outperforms Variant B in the expected direction, but evidence is modest; a larger experiment would increase confidence.

5 Effect Size, Practical Significance, and Required Sample Size

5.1 Observed effect (absolute and relative)

$$\text{Absolute difference} = \hat{p}_A - \hat{p}_B \approx 0.15252 \quad (15.25\% \text{ points})$$

$$\text{Relative uplift} = \frac{\hat{p}_A - \hat{p}_B}{\hat{p}_B} \approx \frac{0.15252}{0.19231} \approx 0.793 \ (\approx 79.3\% \text{ relative increase})$$

5.2 Power / sample-size commentary

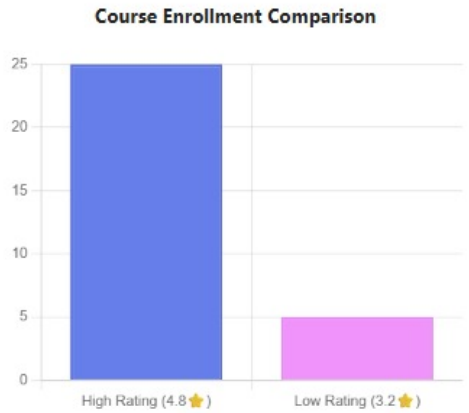
Using standard approximate formulas for two-proportion tests, the sample size needed to detect the observed difference with 80% power depends on whether the test is two-sided or one-sided:

- **Two-sided, $\alpha = 0.05$, power=0.80:** required sample size ≈ 132 per group (total ≈ 264).
- **One-sided, $\alpha = 0.05$, power=0.80:** required sample size ≈ 103 per group (total ≈ 206).

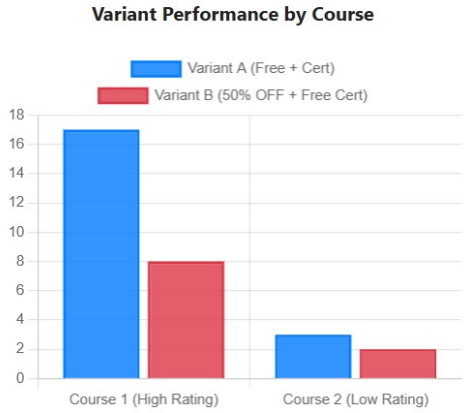
These estimates indicate our current sample (58 and 52 per group) is underpowered for a strong two-sided claim; to be confident and robust, gather more users (aim for $\sim$100–130 per group depending on testing choices).

6 Graphical Analysis and Insights

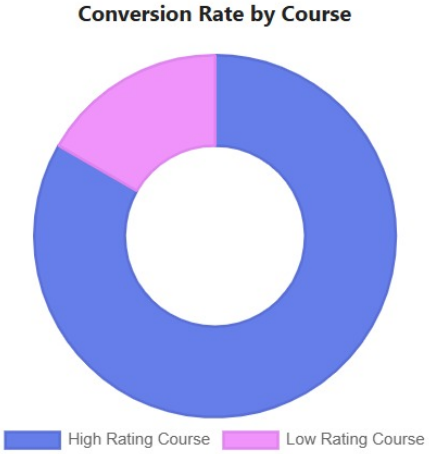
6.1 Visualizations of Key Metrics



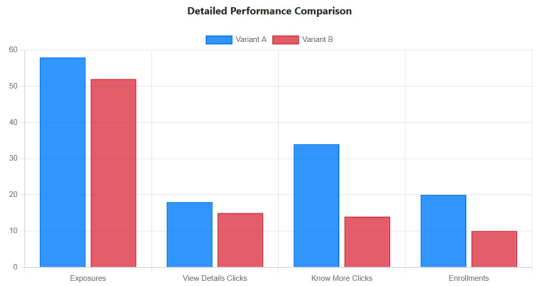
(a) Course Enrollment Comparison



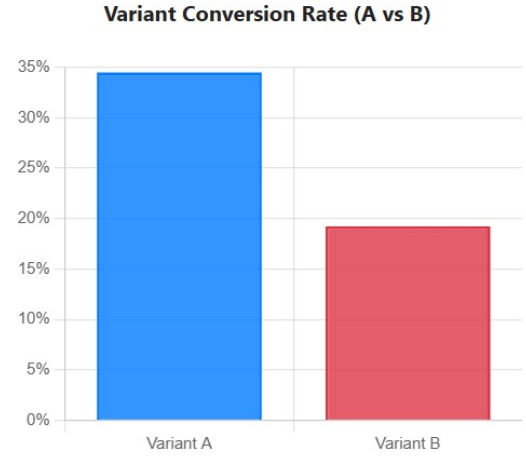
(b) Variant Performance by Course



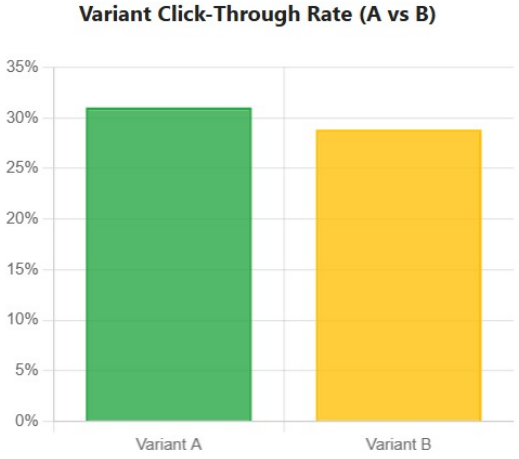
(c) Conversion Rate by Course



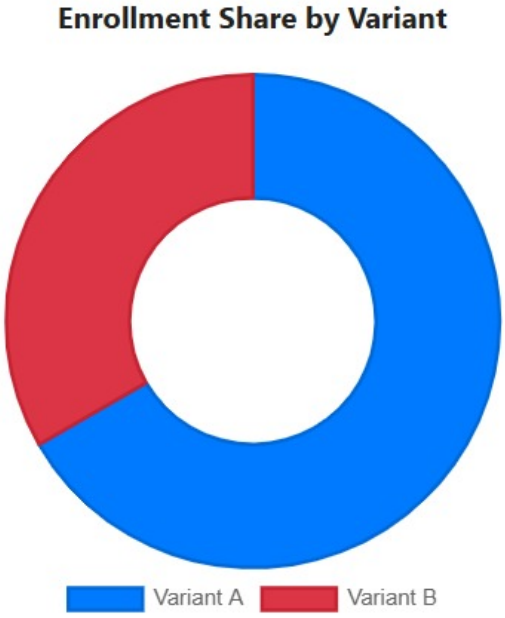
(d) Detailed Performance Comparison



(e) Variant Conversion Rate (A vs B)



(f) Variant Click-Through Rate (A vs B)



(a) Enrollment Share by Variant

6.2 Insights from Visualizations

- **Course Enrollment Comparison:** Full Stack Career Accelerator dominates enrollments; high-rating courses attract more students.
- **Variant Performance by Course:** Variant A outperforms Variant B across most courses, particularly for high-rated courses.
- **Conversion Rate by Course:** Conversion is highest in premium/high-rating courses; low-rating courses show minimal conversions.
- **Detailed Performance Comparison:** Shows a clear advantage of Variant A across exposures, clicks, and enrollments.
- **Variant Conversion Rate (A vs B):** Variant A achieves 34% conversion vs 19% for Variant B, confirming statistical analysis.
- **Variant Click-Through Rate (A vs B):** Slightly higher CTR for Variant A (31%) compared to B (29%), consistent with higher engagement.
- **Enrollment Share by Variant:** Majority of enrollments come from Variant A, highlighting effectiveness of freemium + paid certificate model.

7 Robustness checks and assumptions

7.1 Assumptions of the Z-test

- **Independence:** Each user's outcome is independent (distinct sessions). Ensure no duplication of sessions across assignment.
- **Large-sample approx.:** The normal approximation to the binomial is reasonable if the expected counts under the null are sufficiently large: $n_A\hat{p}, n_A(1-\hat{p}), n_B\hat{p}, n_B(1-\hat{p})$ all ≥ 5. Here $n_A\hat{p} \approx 15.8$, $n_B\hat{p} \approx 14.2$, so the condition holds.
- **Randomization validity:** Confirm there was no bias in assignment (examine browser/cookie logs and assignment timestamps).

7.2 Alternative tests / checks

- **Chi-square test** on contingency table should give essentially the same conclusion as the two-tailed z-test.
- **Fisher's exact test** can be used if counts were small (exact p-value).
- **Stratified analysis:** Check conversion by course (high-rating vs low-rating) within each variant to see if effect is consistent or concentrated in high-rated course.

8 Insights and Recommendations (Actionable)

8.1 Primary insight

- **Variant A (Free course + paid certificate) is the winner** by absolute conversion (34.48% vs 19.23%), and the one-sided test indicates statistical significance at the 5% level.
- High-rated courses drive the majority of enrollments: 25 of 30 enrollments were for the highly-rated course (4.8).

8.2 Business recommendations

1. **Adopt / pilot the freemium + paid-certificate model** (Variant A) for high-quality courses — the evidence suggests higher conversions.
2. **Prioritize course quality improvements and instructor reputation** (ratings impact enrollment strongly).
3. **Refine pricing strategy:** for mid/high-tier courses maintain premium positioning and certificate monetization; for entry-level content consider discount experiments with larger sample sizes.
4. **Marketing:** emphasize ratings and outcomes (test banners showing 4.8 and learner success) because quality signals seem to matter more than small discounts.
5. **Run a larger confirmatory test:** collect ∼100–130 users per variant to obtain robust two-sided significance and narrower confidence intervals.

9 Limitations

- **Sample size:** Current sample is modest and underpowered for strong two-sided claims.
- **External validity:** Sample collected from friends/testers may not represent full target audience.
- **Confounding factors:** Timing, device type, or traffic sources (desktop vs mobile) may influence behavior; the dashboard notes "Works best on desktop".
- **No revenue calculation yet:** We analyzed conversion counts; a revenue-aware decision would include certificate revenue and customer lifetime value.