Virtual Presentation: Featured Research

INNOVATIVE LEARNING ANALYTICS FOR EVALUATING EFFECTIVENESS OF FIRST PRINCIPLES OF INSTRUCTION

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Summary

We describe a forward-thinking research methodology that uses big data to evaluate the effectiveness of online instruction. Analysis of Patterns in Time (APT) is a practical analytic approach that analyzes meaningful patterns in massive data sets, capturing temporal maps of students' learning journeys by combining qualitative and quantitative methods. We demonstrate how APT can yield strong, easily generalizable empirical evidence through big data, documenting the extraordinary effectiveness of First Principles of Instruction.

Overview

- Three naturalistic design-research studies of the online Indiana University Plagiarism Tutorials and Tests (IPTAT) for evaluating effectiveness of Merrill's First Principles of Instruction
- Focus on Study #3 today
- How we used Google Analytics 4 (GA4) to do Analysis of Patterns in Time (APT) of over 172,000 student learning journeys through IPTAT
- How we further used Excel spreadsheets to derive APT likelihoods, conditional probabilities, and odds ratios for Bayesian analysis
- Results and conclusions

IPTAT Facts: Indiana University Plagiarism Tutorials and Tests: 2002 - 2021

- Originally designed in 2002 as an online resource for students in Instructional Systems Technology (IST) at IU
- Soon found on the Web and adopted by many instructors, not only at IU, but from across the U.S. and other countries
- Approximately 144 million pageviews since 2002
- Significant IPTAT redesign 2013 – 2015
- New tutorials designed with First Principles of Instruction, first available on Jan. 2, 2016
- Big data: since 2016

  ~ 103 million IPTAT pageviews

  ~ 890,000 Certificates awarded to students who passed one of trillions of randomized Certification Tests, who were 14 – 44+ years old, from 225 countries and territories worldwide

IPTAT Design Teams

- Legacy version: 2002 -2015
  - *Ted Frick, Elizabeth Boling, Meltem Albayrak-Karahan, Joseph Defazio, Noriko Matsumura, Cesur Dagli, Rodney Myers, Andrew Barrett*
- New design based on First Principles of Instruction: 2016 - present
  - *Ted Frick, Cesur Dagli, Rodney Myers, Kyungbin Kwon, Kei Tomita, Eulho Jung*
- Main goal: to help students identify
  - *Word-for-word plagiarism*
  - *Paraphrasing plagiarism*
  - *Non-plagiarism*
- Secondary goal:
  - *To evaluate effectiveness of IPTAT via naturalistic design-research studies*

IPTAT Design-Research Studies

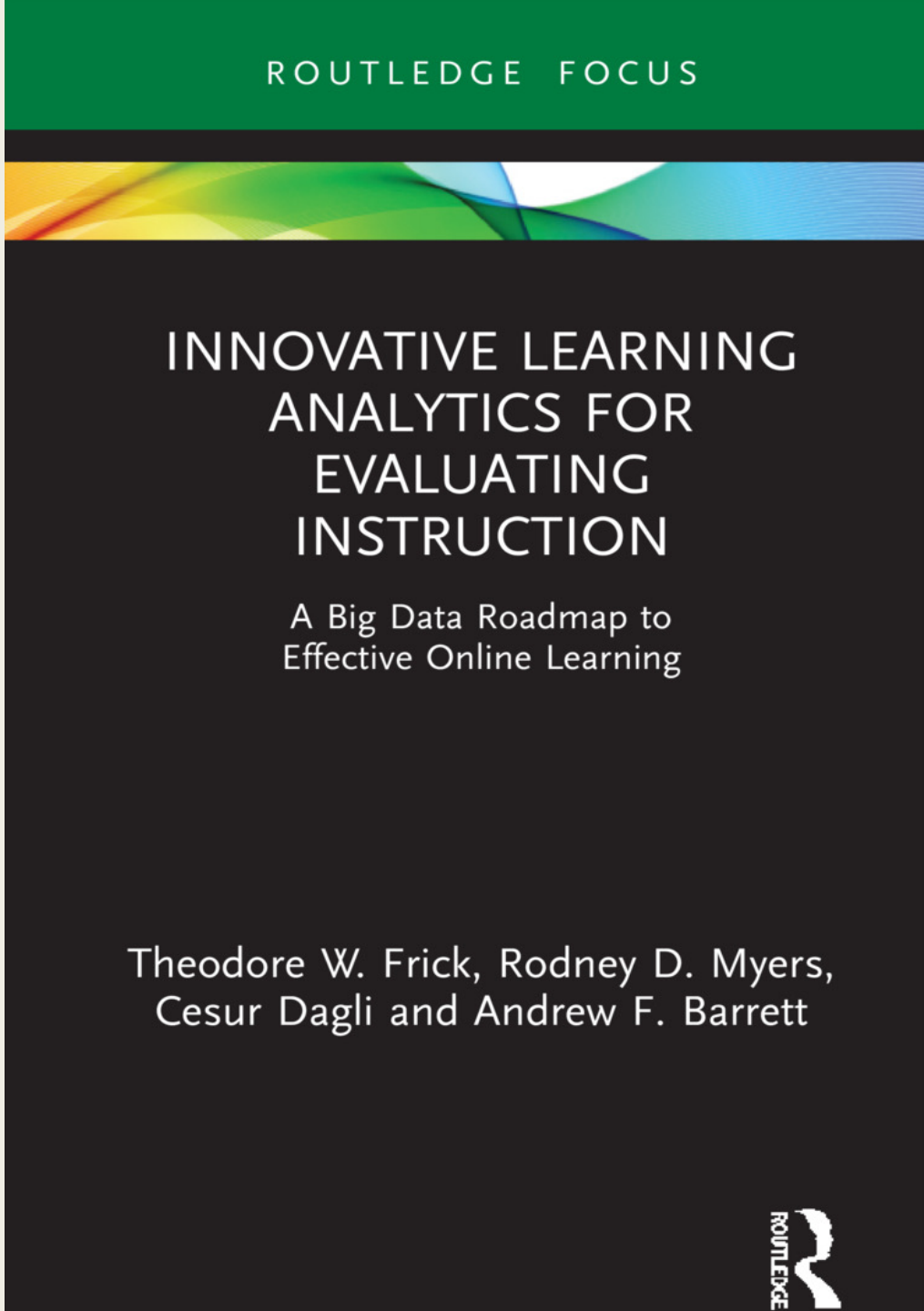
- Study 1 (2016 data): Frick & Dagli (2016)
- Study 2 (2019-2020 data): Frick, Myers, Dagli & Barrett (2022)
- Study 3 (early 2021 data): Current study: Frick, Myers & Dagli (under review at ETR&D)

Study 1: MOO-TALQ: Massive Open Online Teaching and Learning Quality

- MOO-TALQ used to survey student *perceptions* of their experiences with IPTAT
- About 2,000 students in Jan. 2016 took the MOO-TALQ survey before taking an IPTAT Certification Test
- Those students who next passed the IPTAT Certification Test: 'High masters'
- Main findings
  - Graduate students who agreed that they experienced First Principles of Instruction (FPI) and Academic Learning Time (ALT, successful engagement) were about 5 times more likely to be 'high masters' than were those who disagreed that they experienced FPI and ALT
  - Undergrad students who agreed that they experienced FPI and ALT were about 3 times more likely to be 'high masters', when compared with those who disagreed

Study 2: Big Study over 2 years, 2019-2020

- Approximately 936,000 learning journeys, students from 222 countries and territories worldwide
- About 1.9M temporal maps, 36M pageviews
- Google Analytics for tracking student use of IPTAT website
- Discovered in 2020 that Universal Analytics (UA) could be leveraged to do Analysis of Patterns in Time (APT) when coupled with Excel spreadsheets
- Main APT finding: Successful students viewed 3 to 4 times as many unique Web pages designed with First Principles of Instruction as did unsuccessful students.



Study 3: Current Study: Early 2021—Under Review at ETR&D

- 172,000+ learning journeys, Jan. 1 through March 25, 2021
- Students from 186 countries worldwide
- ~330K temporal maps, 8M views of Web pages designed with First Principles
- Google Analytics for tracking student use of IPTAT website
- New version of Google Analytics (GA4) leveraged to do Analysis of Patterns in Time (APT), also coupled with Excel spreadsheets
- Main APT finding: Likelihood of student achievement was nearly 4 times greater when they engage with one or more tutorial webpages designed with First Principles of Instruction, when compared with nonmasters
- Overall, GA4 made it easier to do APT with Excel than did Universal Analytics.

HOW DID WE DO STUDY 3?

Main Research Questions

1. What is the likelihood of achieving mastery when students select IPTAT instruction designed with First Principles of Instruction (FPI)?
2. Can Google Analytics 4 (GA4) be used to do Analysis of Patterns in Time (APT)? If so, how?

First Principles of Instruction (FPI): Merrill (2002, 2013, 2020)

1. ***Authentic problems or tasks*** for students to do, arranged from simple to complex (e.g., https://plagiarism.iu.edu/tutorials/index.html);
2. ***Activation*** of student learning by helping students connect new learning with what they already know or believe (e.g., https://plagiarism.iu.edu/tutorials/task1/activation.html);
3. ***Demonstration*** of what is to be learned, by showing a variety of examples (e.g., https://plagiarism.iu.edu/tutorials/task1/demonstration.html);
4. ***Application*** of what is being learned, so students can try themselves and feedback is provided (e.g., https://plagiarism.iu.edu/practiceTest.php?task=1&item=1); and
5. ***Integration*** of what has been learned into students' own lives (e.g., https://plagiarism.iu.edu/tutorials/task1/integration.html).

Basic Level: Recognize the basic difference between:

- *avoiding* plagiarism, and
- *committing* plagiarism.

Novice Level: When *one source is used*, recognize a proper quotation from an improper quotation:

- a *proper quotation* of someone else's words, and
- provision of the appropriate citation and reference.

Intermediate Level: When *one source is used*, recognize a proper paraphrase from an improper paraphrase:

- a *proper paraphrase* of someone else's words, and
- provision of the appropriate citation and reference.

Advanced Level: When *one source is used*, recognize various combinations of:

- *proper/improper paraphrasing*, and
- *proper/improper quotations.*

Expert Level: Put it all together. When *two or more sources are used*, recognize various combinations of:

- *proper/improper paraphrasing*, and
- *proper/improper quotations.*

IPTAT TUTORIALS DESIGN IN 2015

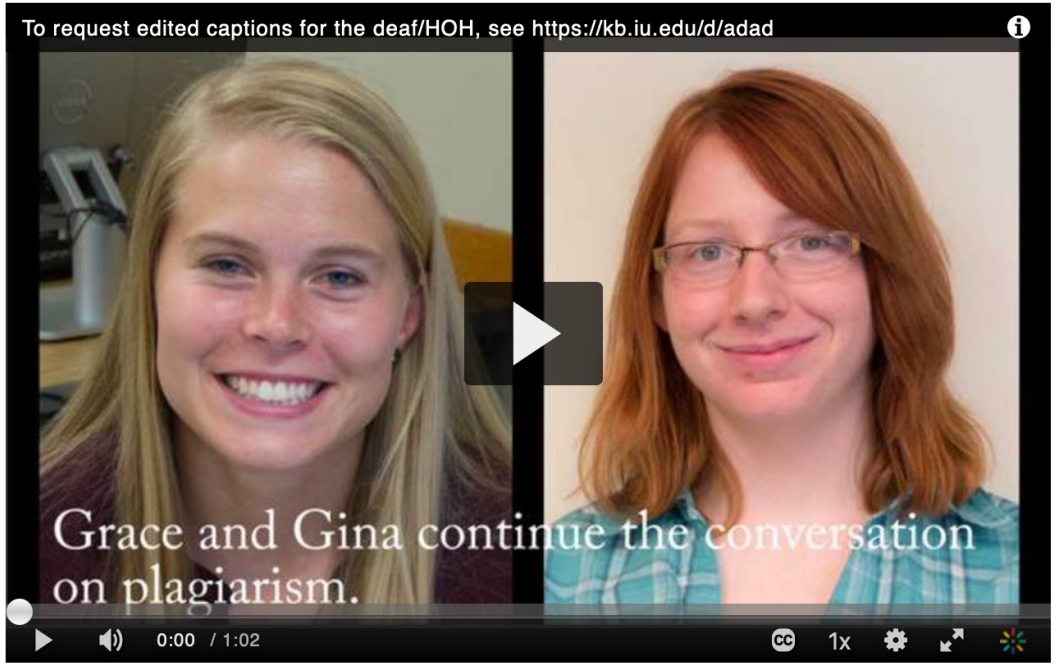
Apply First Principle #1: sequence ***authentic tasks*** from simple to complex

How to Recognize Plagiarism: Tutorials and Tests

Instruction: ***Novice Level***

A Video Case

Grace and Gina discuss how to properly quote someone else's words and to cite the author(s). Click the one-minute video below to view this case.



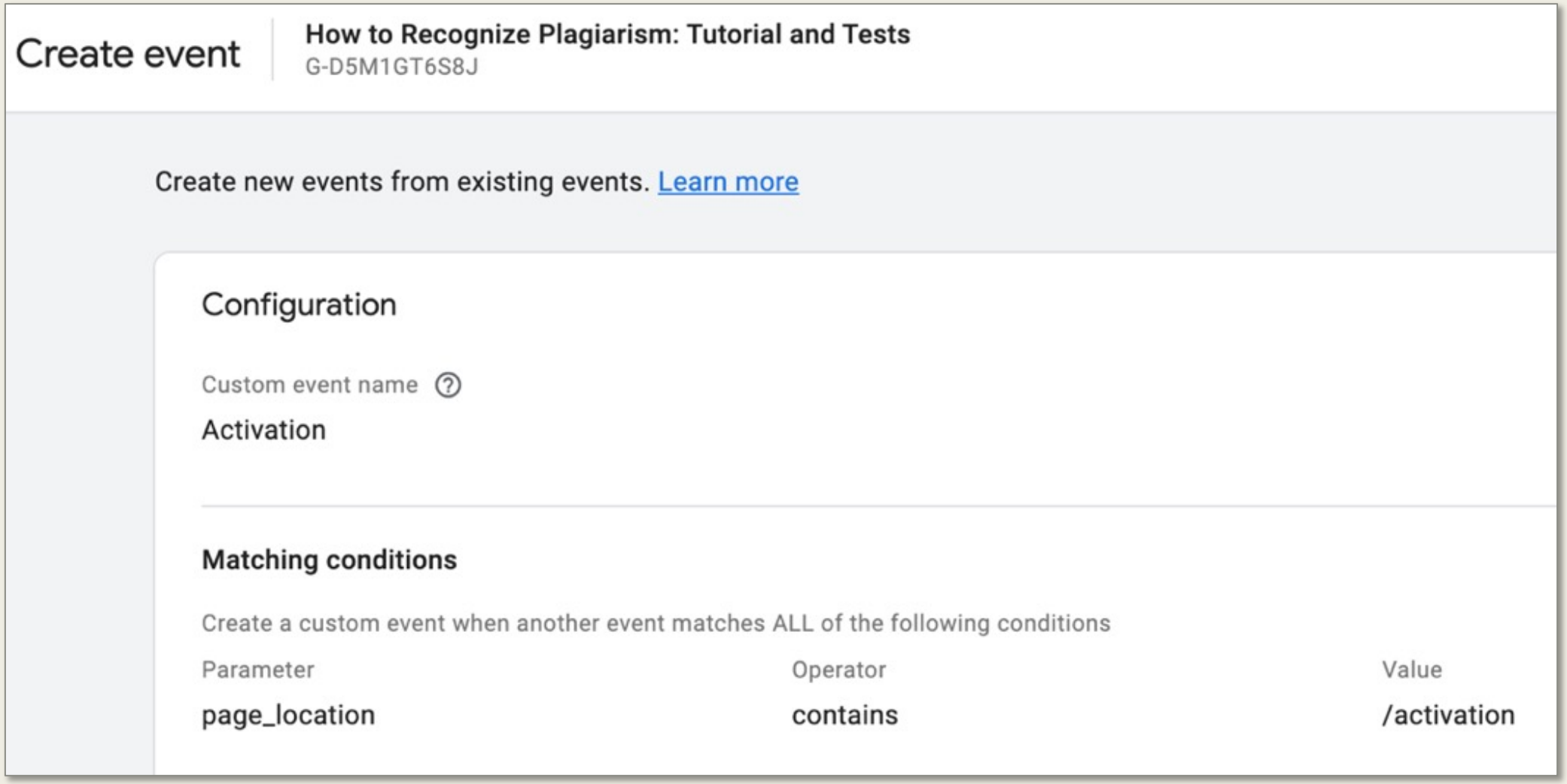
IPTAT DESIGN EXAMPLE

Applying First Principle #2: *Activation*

Task Level	Level Name	First Principle	Pages/ Instances	Page URLs at https://plagiarism.iu.edu
1	Basic	Activation	1/1	/tutorials/task1/activation.html
		Demonstration	2/4	/tutorials/task1/demonstration.html /tutorials/task1/demonstration2.html
		Application	4/4	/practiceTest.php?task=1&item=1 … 4
		Integration	1/1	/tutorials/task1/integration.html
		Practice Test	1/4	/tutorials/task1/masteryTest.php
2	Novice	Activation	1/1	/tutorials/task2/activation.html
		Demonstration	1/2	/tutorials/task2/demonstration.html
		Application	4/4	/practiceTest.php?task=2&item=1 … 4
		Integration	1/1	/tutorials/task2/integration.html
		Practice Test	1/4	/tutorials /task2/masteryTest.php
3	Intermediate	Activation	1/1	/tutorials/task3/activation.html
		Demonstration	1/2	/tutorials/task3/demonstration.html
		Application	4/4	/practiceTest.php?task=3&item=1 … 4
		Integration	1/1	/tutorials/task3/integration.html
		Practice Test	1/4	/tutorials /task3/masteryTest.php
4	Advanced	Activation	2/2	/tutorials/task4/activation.html /tutorials/task4/activation2.html
		Demonstration	1/2	/tutorials/task4/demonstration.html
		Application	8/8	/practiceTest.php?task=4&item=1 … 8
		Integration	1/1	/tutorials/task4/integration.html
		Practice Test	1/8	/tutorials /task4/masteryTest.php
5	Expert	Activation	3/3	/tutorials/task5/activation.html /tutorials/task5/activation2.html /tutorials/task5/activation3.html
		Demonstration	1/2	/tutorials/task5/demonstration.html
		Application	10/10	/practiceTest.php?task=5&item=1 … 10
		Integration	1/1	/tutorials/task5/integration.html
		Practice Test	1/10	/tutorials /task5/masteryTest.php
All	Patterns	Demonstration	19/18	/plagiarismPatterns/…

STRUCTURE: IPTAT TUTORIALS DESIGN IN 2015

GA4: Create New Conversion Events



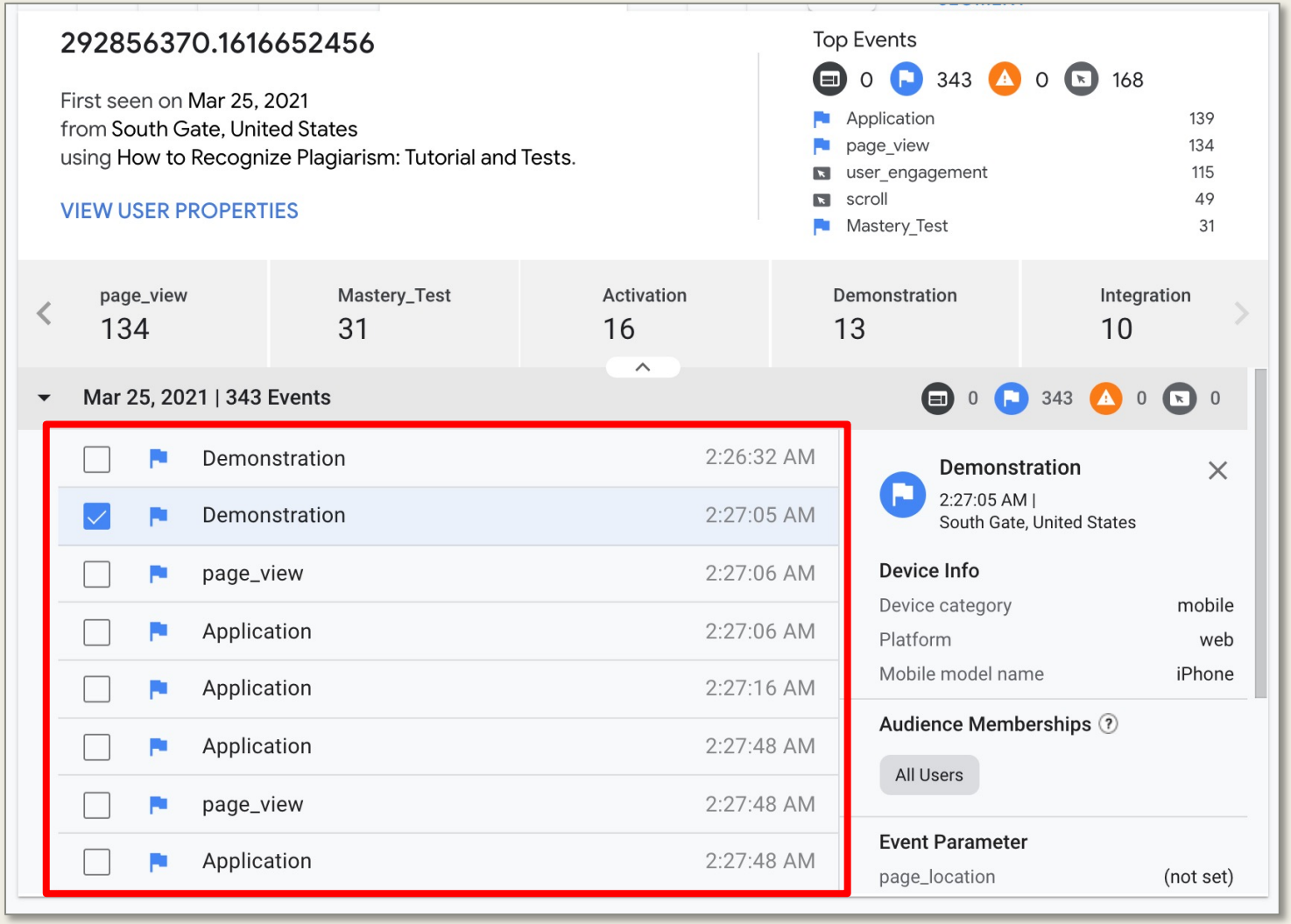
Event Name	Marked as conversion
Activation	TRUE
Application	TRUE
click	FALSE
Demonstration	TRUE
file_download	FALSE
first_visit	FALSE
Integration	TRUE
Mastery_Test	TRUE
page_view	TRUE
Pass_GR_Test	TRUE
Pass_UG_Test	TRUE
Plagiarism_Patterns	TRUE
Plagiarism_Test	TRUE
scroll	FALSE
session_start	FALSE
Test_Feedback	TRUE

GA4 EVENTS

CREATE NEW CONVERSIONS (GA4 GOALS)

Note: new conversion event names begin in uppercase; events that GA4 tracks by default are lowercase names.

GA4 Explorer Excerpt: APT Temporal Map of a *Student Learning Journey*



GA4 ANALYSIS PROCEDURES

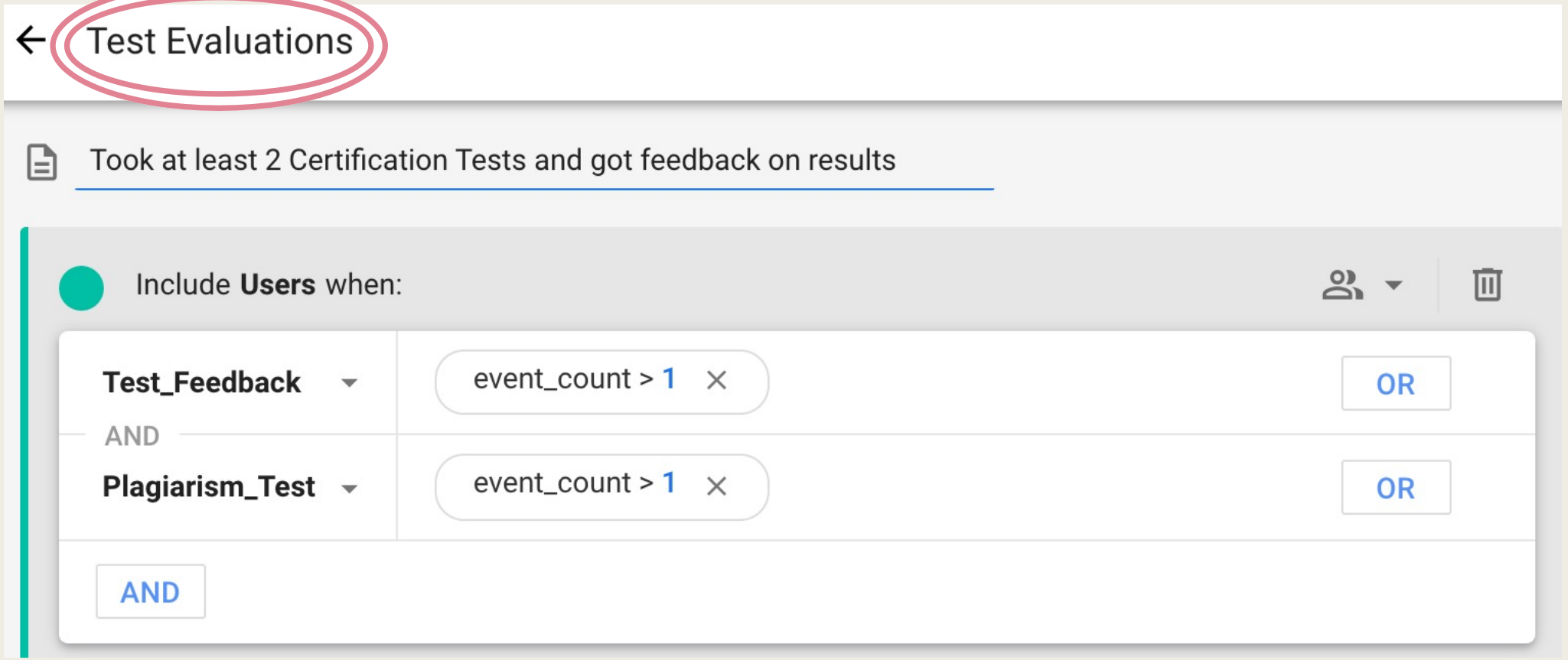
Define GA4 segments needed for APT Queries

Demonstrations of GA4 Analytic Procedures

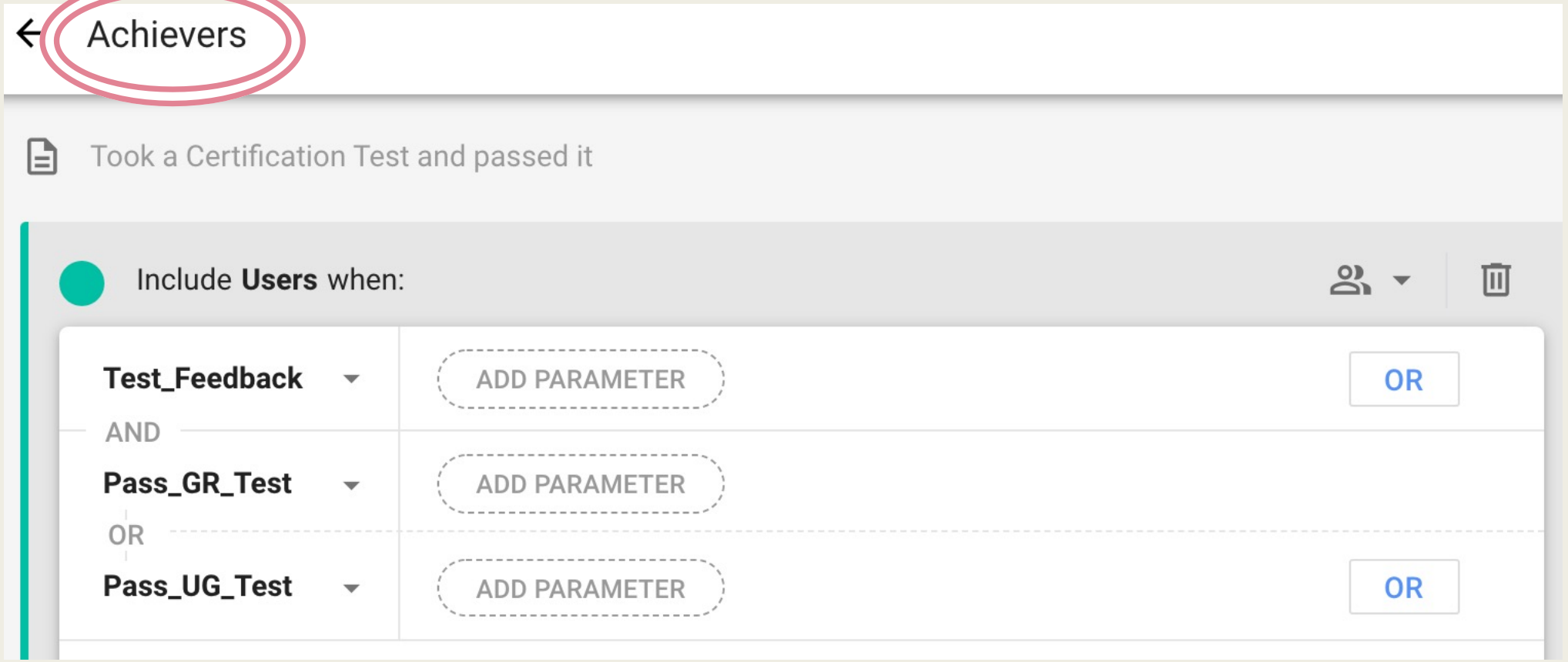
See video demonstrations of how to do APT with GA4 at:

https://plagiarism.iu.edu/apt/

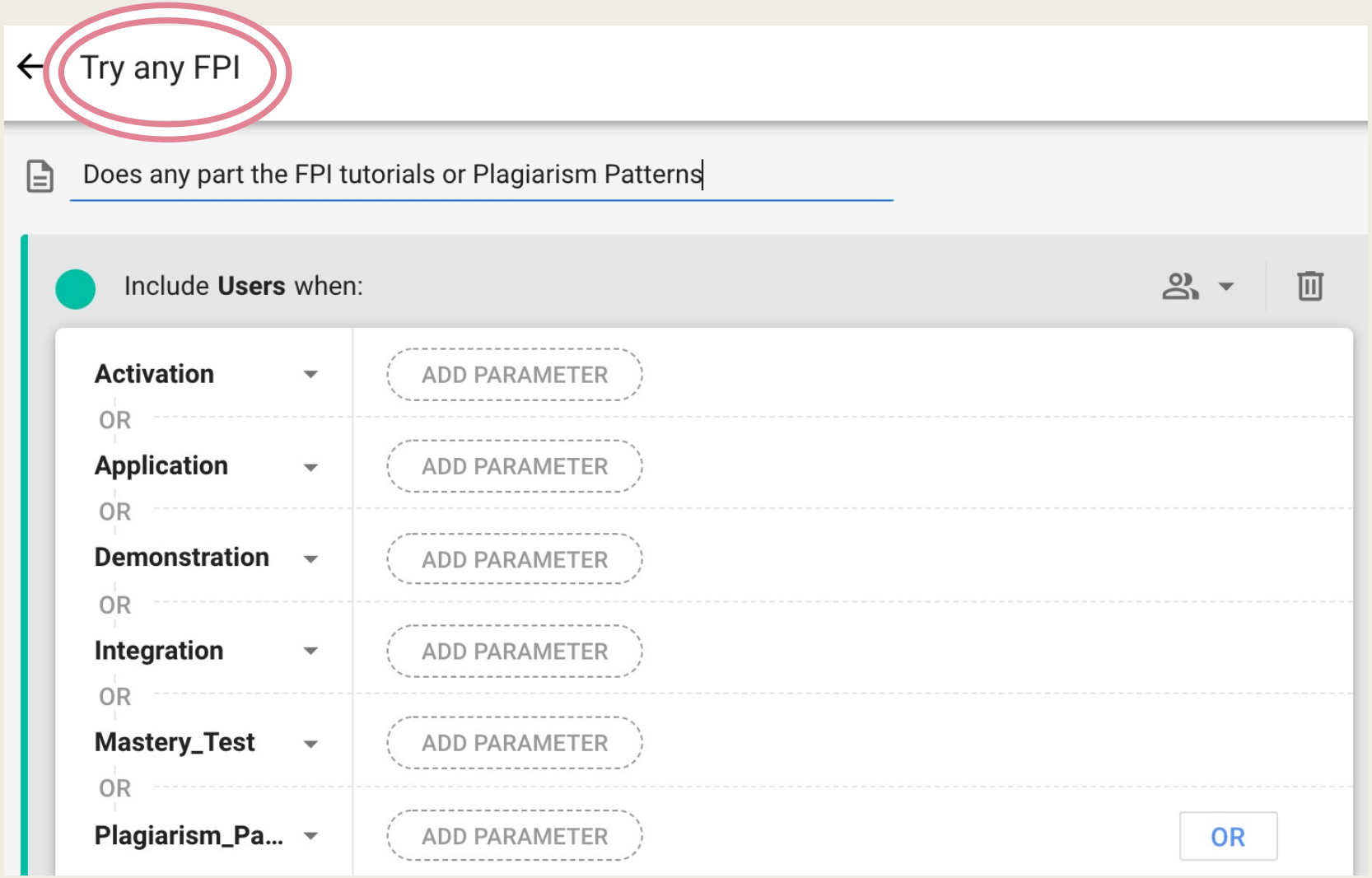
GA4 Segment Definition: for APT Queries

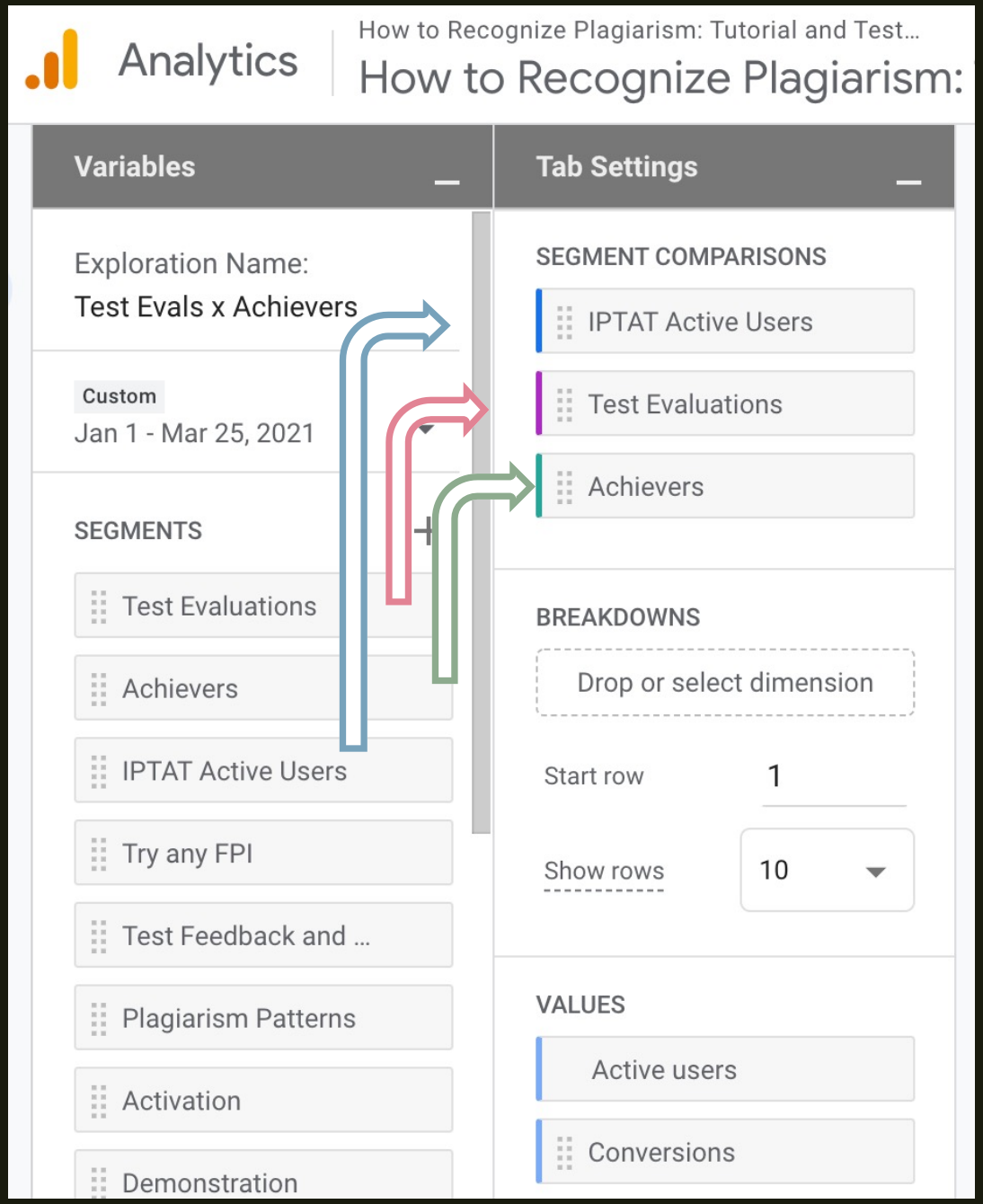


GA4 Segment Definition: for APT Queries



GA4 Segment Definition: for APT Queries

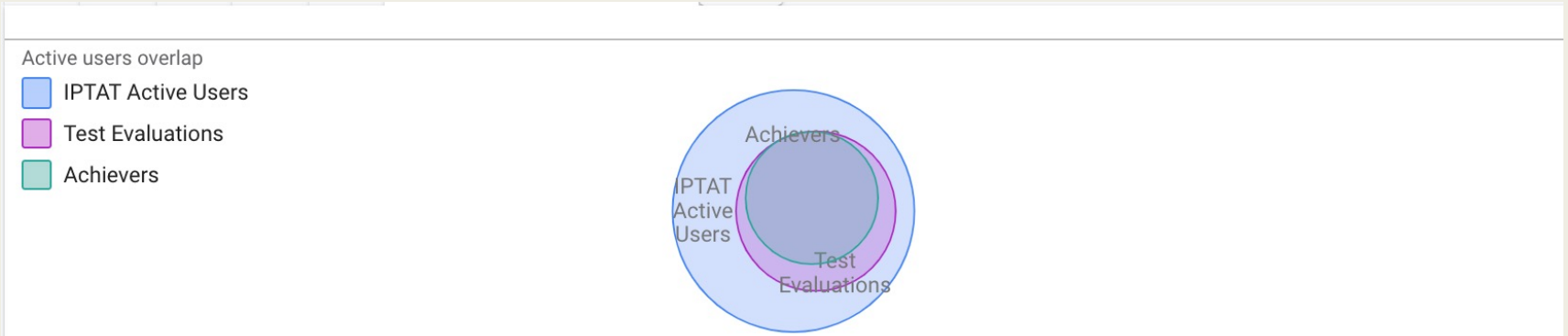




GA4 ANALYSIS:

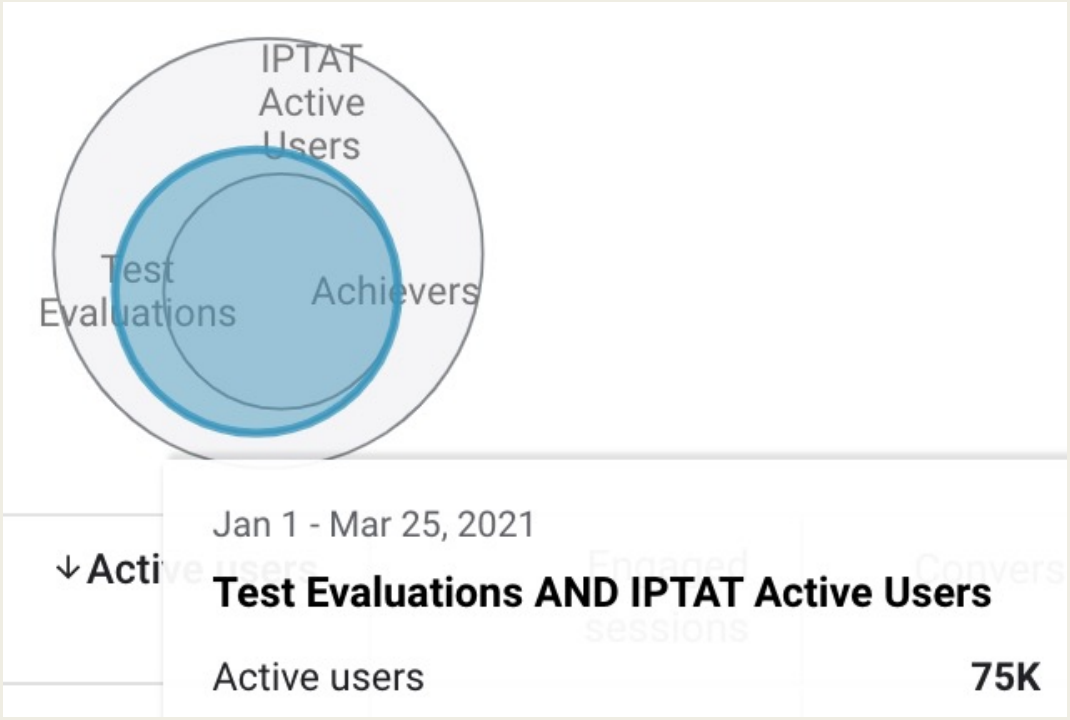
SEGMENT OVERLAP SETUP

GA4 Segment Overlap Analysis Report: All Users

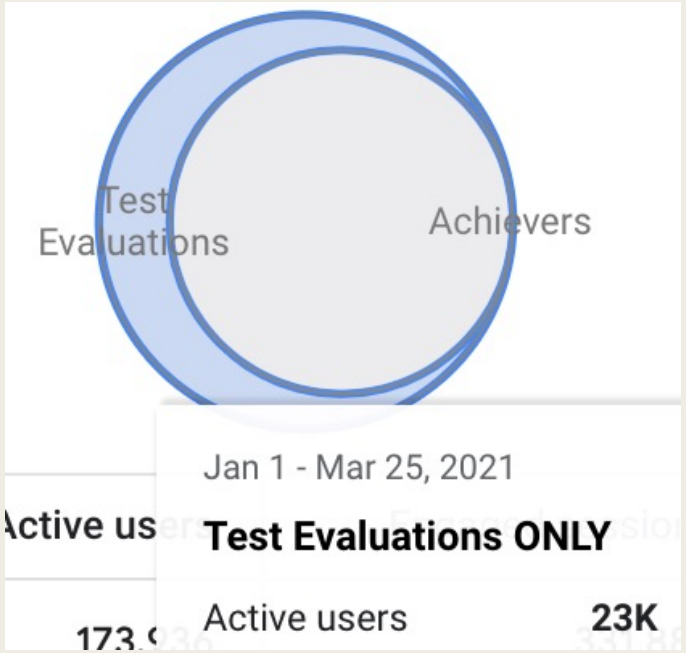


Segment set		↓ Active users	Engaged sessions	Conversions	User engagement
	Totals*	**173,936** 100% of total	**331,884** 100% of total	**16,547,092** 100% of total	**11y 110d** 100% of total
1	IPTAT Active Users	172,329	330,078	16,549,275	11y 109d
2	IPTAT Active Users ONLY	96,987	127,403	1,641,404	226d 23h
3	Test Evaluations	75,087	202,667	14,910,783	10y 248d
4	IPTAT Active Users + Test Evaluations	75,043	202,667	14,907,729	10y 247d
5	Achievers	51,648	135,943	11,212,373	7y 275d
6	Test Evaluations + Achievers	51,646	135,935	11,212,169	7y 275d

Exclude the Dabblers (97K). Keep those who have Test Evaluations (75K)



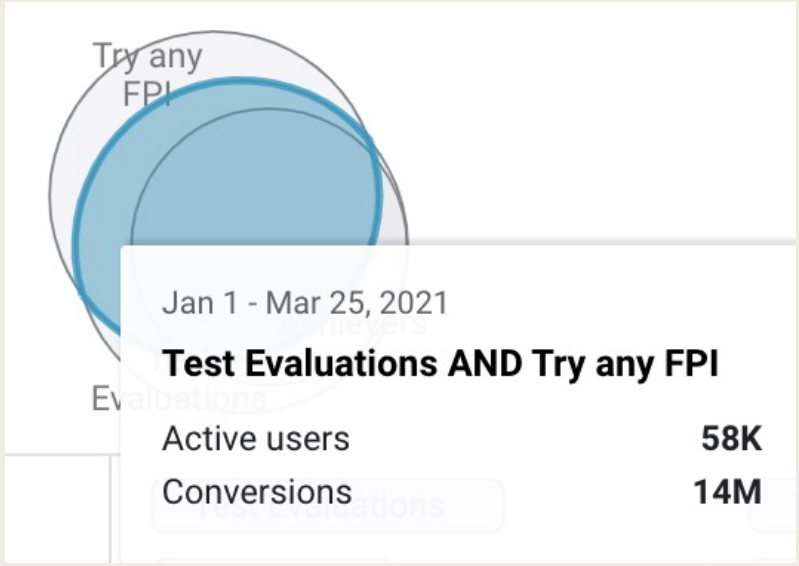
75K took 2 or more tests. 52K passed (Achievers); 23K did not pass (Nonmasters)

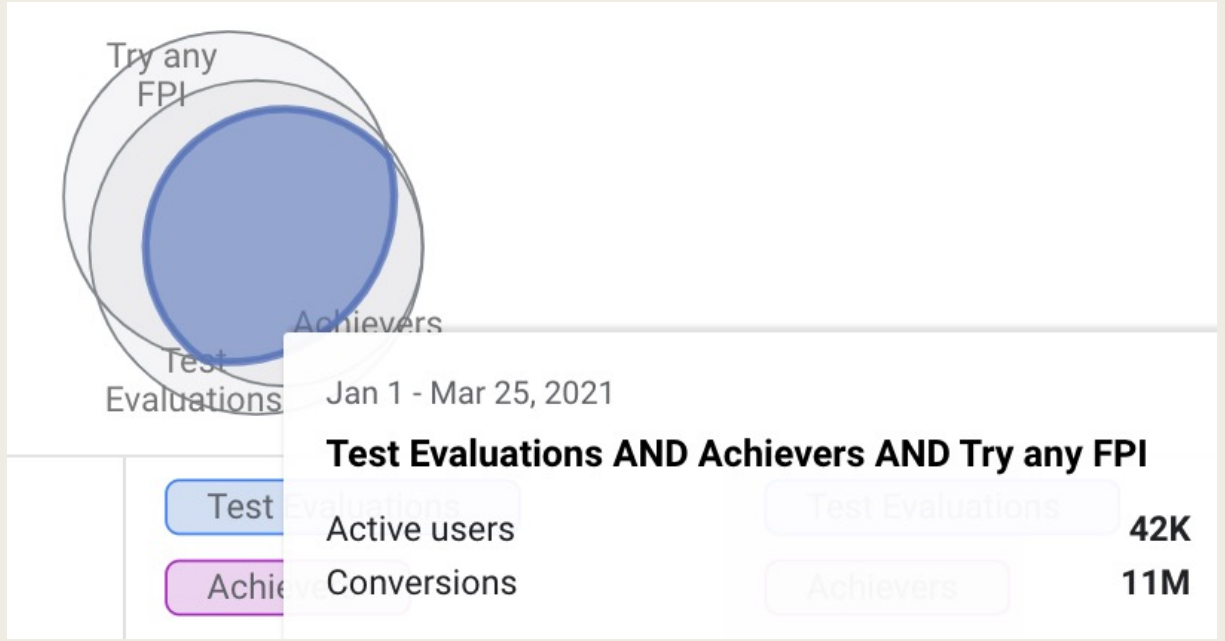


New Segment Overlap: Exclude Dabblers and add segment: Try any FPI

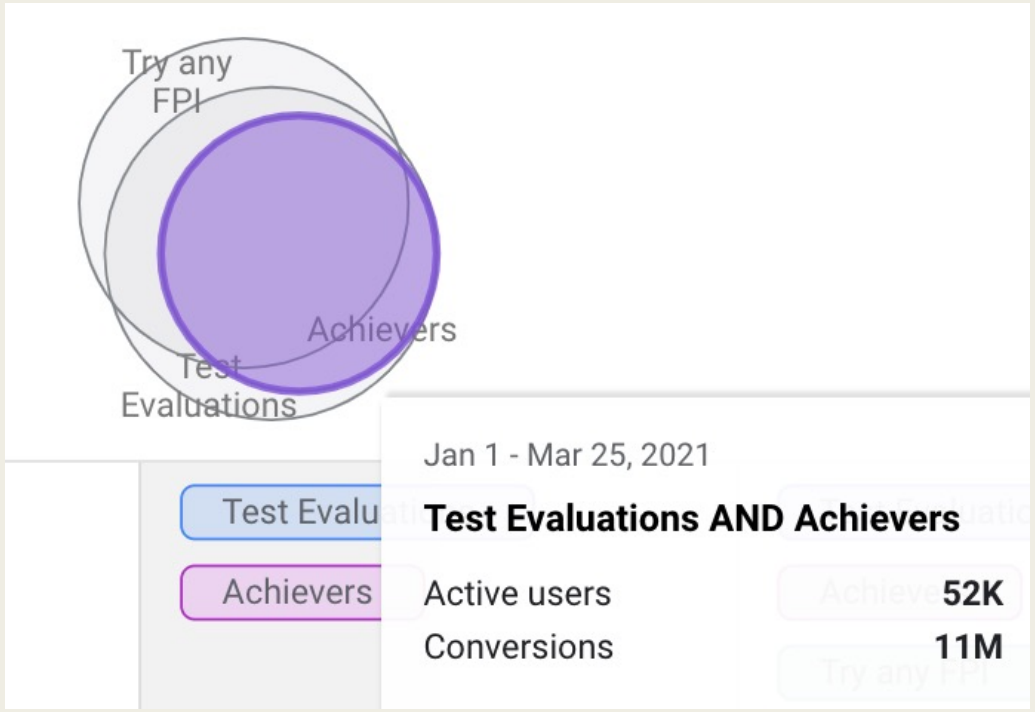
	Segment set	Test Evaluations + Try any FPI		Achievers		Test Evaluations + Achievers		Test Evaluations + Achievers + Try any FPI	
	Event name	Active users	Conversions	Active users	Conversions	Active users	Conversions	Active users	Conversions
10	Activation	27,604	350,283	21,416	281,842	21,416	281,842	21,416	281,842
11	Mastery_Test	27,392	695,593	21,488	554,001	21,488	554,001	21,488	554,001
12	Application	26,980	3,185,806	21,362	2,567,369	21,362	2,567,369	21,362	2,567,369
13	Demonstration	27,078	311,811	21,202	248,736	21,202	248,736	21,202	248,736
14	Integration	25,081	205,059	19,998	165,748	19,998	165,748	19,998	165,748
15	Pass_GR_Test	9,839	25,689	11,172	29,150	11,164	29,135	9,839	25,689

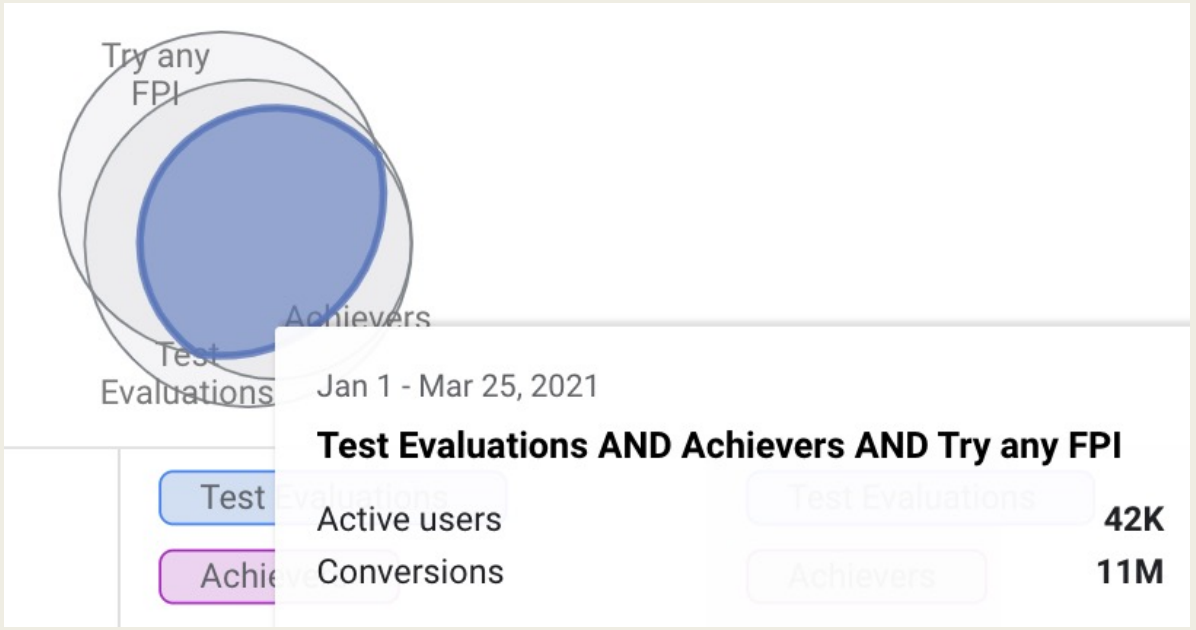
58K who took tests had Tried any FPI, and of those, 42K were Achievers.



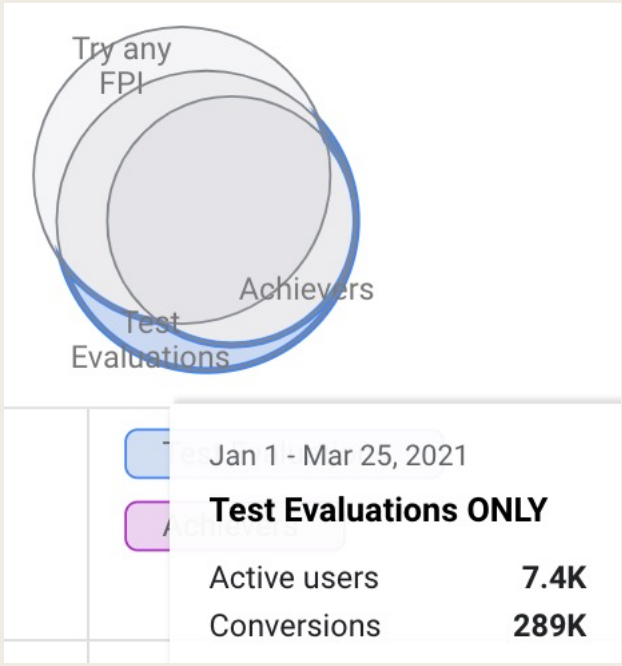


Since 52K passed, and 42K had Tried any FPI, then about 10K passed without trying any FPI (Minimalist Achievers)





23K had failed 2 or more tests (Nonmasters). 52K had passed (Achievers). 7.4K were Nonmasters who had *not* Tried any FPI. 23K - 7.4K = 15.6K were Nonmasters who *had* Tried any FPI.



RESULTS: STUDY 3

Results: Untested & Tested Users

Segment set	Active users	Conversions	Engaged sessions	Seconds of user engagement
IPTAT Users ONLY (Untested Users)	96,895	1,638,247	127,212	19,538,040
Test Evaluations (Tested Users)	75,206	14,914,940	202,827	337,158,334
Total Learning Journeys	172,101	16,553,187	330,039	356,696,374

Results: Further Breakdowns

Segment set	Active users	Conversions	Engaged sessions	Seconds of user engagement
Test Evaluations (Tested Users)*	75,206	14,914,941	202,828	337,158,334
Achievers	51,648	11,212,373	135,944	244,722,736
Test Evaluations ONLY (Nonmasters)	23,405	3,702,581	66,887	92,435,598
Achievers ONLY (Already Achievers)	3	13	3	~
Achievers and Nonmasters Total	75,053	14,914,954	202,831	337,158,334

Results: Derived via Excel Spreadsheet

Segment set	Conversions per User	Sessions per User	Min. of Engaged Time per User
Test Evaluations (Tested Users)	198.3	2.7	74.7
Achievers	217.1	2.6	79.0
Test Evaluations ONLY (Nonmasters)	158.2	2.9	65.8
Achievers ONLY (Already Achievers)	4.3	1.0	~

Segment set Event name	Achievers Active users	Achievers Conversions	Nonmasters Active users	Nonmasters Conversions
	51,648	11,212,373	23,405	3,702,581
page_view	51,648	4,338,323	23,405	1,427,673
Plagiarism_Test	51,648	1,015,210	23,405	514,313
Test_Feedback	51,648	1,158,217	23,405	542,610
Activation	21,416	281,842	6,108	68,526
Demonstration	21,202	248,736	5,871	63,163
Application	21,362	2,567,369	5,608	619,540
Integration	19,998	165,748	5,069	39,378
Mastery_Test	21,488	554,001	5,866	141,760
Plagiarism_Patterns	33,601	750,641	13,504	285,617
Pass_GR_Test	11,169	29,147	0	0
Pass_UG_Test	40,561	103,126	0	0

Results:

GA4 Breakdown by Event Names

APT Results: Bayesian Analysis

Segment set Event name	*p*(A)	*p*(N)	*p*(A | FPI)	*p*(N | FPI)	Odds (A:N)
Activation	0.29	0.08	0.78	0.22	3.51
Demonstration	0.28	0.08	0.78	0.22	3.61
Application	0.28	0.07	0.79	0.21	3.81
Integration	0.27	0.07	0.80	0.20	3.95
Mastery_Test	0.29	0.08	0.79	0.21	3.66
Plagiarism_Patterns	0.45	0.18	0.71	0.29	2.49

Key

A Achiever
N Nonmaster
p probability
| given

FPI First Principle of Instruction

CONCLUSIONS

Main Findings from Analysis of Patterns in Time (APT)

- Likelihood of student achievement was nearly 4 times greater when they engage with one or more tutorial webpages designed with First Principles of Instruction.
- GA4 made it easier to do APT, when compared with Universal Analytics (UA, the previous Google Analytics reporting tool).

Main Findings from Analysis of Patterns in Time (APT)

- GA4 could be set up initially to classify instances of First Principles of Instruction as part of its tracking system for storing temporal maps
- Segment Overlap analysis tool, new in GA4, made it
  - *easier to create segments of active users, according to what they did in IPTAT*
  - *to separate IPTAT Dabblers from Traditionalists and Minimalists, which we were unable to do with Universal Analytics in Study 2*

With GA4 Segment Overlap analysis to do APT, we now know that about

- 80 percent of Achievers use at least one part of FPI-designed instruction (Traditionalists)
- 20 percent of Achievers primarily use test feedback and hints, but no FPI-designed instruction (Minimalists)
- 56 percent of Active Users do not take multiple Certification Tests and spend little time on the IPTAT website (Dabblers)

A Final Analogy

- Those who have receive two doses of COVID Vaccines are more likely to survive than those who receive one dose or not. That is why medical researchers recommend people receive two doses of Moderna or Pfizer. And now, they recommend a booster dose for further protection against dying from COVID.
- Similarly, we say from our APT results that students who choose one or more IPTAT webpages designed with First Principles of Instruction were nearly 4 times more likely to be successful.

IMPORTANT LINKS

- IPTAT: https://plagiarism.iu.edu
- *Innovative Learning Analytics for Evaluating Instruction* (new book, now available)
- Resources for Analysis of Patterns in Time (includes video demonstration of GA4 analyses and reports)

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