RESILIENCE OF PASSION-DRIVEN STATISTICS

IN THE FACE OF PANDEMIC ONLINE LEARNING

CALIFORNIA STATE UNIVERSITY, CHICO

ROBIN DONATELLO, PHD

COURTNEY MERRICK, MS, RDN

BACKGROUND

THE STUDENT EXPERIENCE IN INTRODUCTORY STATISTICS

Students often believe statistics class will be a negative experience

Less likely to pursue related careers or apply statistical reasoning to evidence-based practices

Engagement and satisfaction are critical to the pursuit of STEM careers and creating educated decision-makers

Project-based learning shown to increase student engagement and "deep-learning": the capacity to enact knowledge to solve a problem requires a deeper level of science understanding than memorizing information or procedures.

(Cobb, 2007; Koparan, 2014; Miller, 2019; Onwuegbuzie, 1997; Petocz & Reid, 2005)

PASSION-DRIVEN STATISTICS (PDS) DESIGNED TO INSPIRE AND PROMOTE DEEP LEARNING

| Inquiry | Data Management | Analysis | Peer Review | Communication Results |

- Outcome of an NSF IUSE grant awarded to Lisa Dierker (Psychology & Education Studies at Wesleyan University)

- GAISE compliant

- Project-based learning → student-directed research

- Statistical analysis software: SPSS, R, Python, SAS, STATA

- Transcends departmental boundaries

Curriculum website https://passiondrivenstatistics.wescreates.wesleyan.edu/
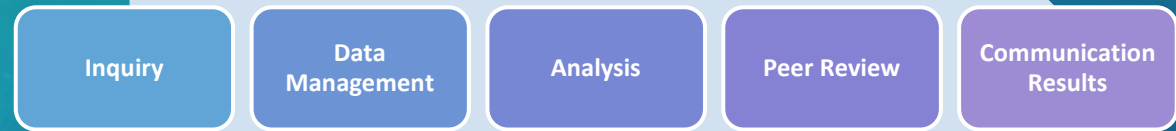
IMPACT OF THE PDS MODEL

Attracts more diverse population of students

Reports more individualized support

Rated as more useful and more rewarding (true research experience)

Increases student confidence in conducting statistical analysis correctly

Greater interest in statistics (course enrollment and research work)

Improved perceived learning gains

Dierker (2015), Dierker (2018), Spence (2022), Nazzaro (2020)

EQUITY PANDEMIC ONLINE LEARNING

- Several studies have looked at student experiences during the pandemic, few have compared course-specific achievement of learning outcomes to pre-pandemic semesters

- Concern that the sudden shift to distance learning widened the equity gap for traditionally marginalized and low-income students who reported increased challenges (e.g., caring of siblings, access to technology, financial stress, reduced affiliation)

- Evidence for a small but significant overall negative impact of pandemic distance learning on student performance <u>in all students</u> (two studies each found -0.2 SD reductions)

- Mixed results as to whether underrepresented racial/ethnic minorities (URM), first generation (FG), and/or low-income students had a meaningful negative impact on learning outcomes

- Note: evidence that project-based models offer benefit in online learning environment

Barber (2021); Keibler (2021), Kofoed (2021), Orlov (2021), Morris (2021), Randazzo (2021), Tate (2022)

INQUIRY

RESEARCH QUESTIONS

Were student-reported outcomes of the PDS curriculum affected by transition to an online format during the pandemic?

Were students who are first generation or from an under-represented race/ethnicity differentially affected by the change in format?

METHODS AND ANALYSIS

DATA COLLECTION: PART OF PROGRAM EVALUATION

SELF-REPORT PRE & POST SURVEY

Wesleyan led evaluation

- Demographics

- Attitudes Toward Statistics Scale (ATS*)

- Undergraduate Research Student Self-Assessment (URSSA*)

- Adapted Computer Science Attitude Survey (CSAS*)

- Course engagement & Future statistics & research goals

SECONDARY DATA ANALYSIS

- N=1633 undergraduate students

- 77 different course sections

- 44 different institutions

- 5 semesters (Sp19 – Sp21)
  - Pre-COVID: Sp19 – Fa19
  - COVID Online: Sp20 – Sp21

*Validated scale

OUTCOME MEASURES: POST COURSE GAINS

GAINS

- Thinking Like a Scientist
- Related to Research
- Skills
  - Statistical Analysis
  - Communicating Research
  - Logistics of Research
  - Computer Skills
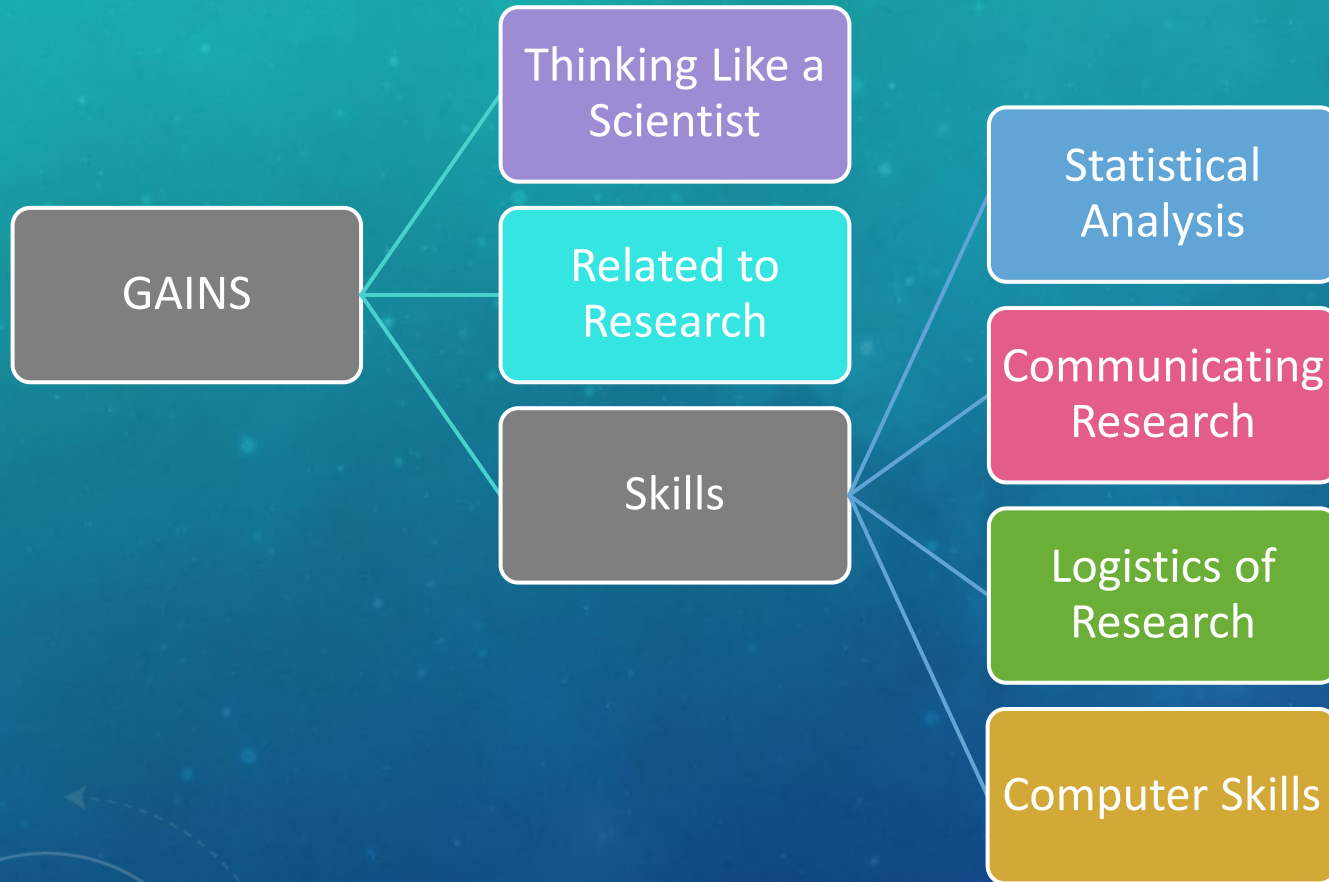
- Likert-scale (0-4) individual questions
- Scales created as an average
- Cronbach's $\alpha = 0.89\text{-}0.95$ indicates high reliability

"How much did you GAIN in choosing the correct statistical test for your question?"

ANALYSIS METHODS

- Exploratory data analysis conducted through univariate, bivariate and multivariable tables and plots.

- Model each gain separately using linear regression while adjusting for:

  - Demographics: gender, ethnicity, first generation status, type of institution

  - Academics: prior interest in conducting research, previous experience in statistics or coding, engagement with course activities, if it was their first statistics course, and if the course in question used a scripting language or a point and click method to work with data.

  - Primary explanatory variable: Course format (Pre-Covid vs Covid online)

  - **Key predictor: Three-way interaction between Format * URM * First Generation**

RESULTS

SAMPLE CHARACTERISTICS

- N=1633 undergraduate students

- 77 course sections at 44 schools

  - Mostly for non-majors

- Majority of students are female, non-URM, non-FG, and from liberal arts colleges *(limits generalizability)*

- Small class sizes on average

- Similar demographics pre-pandemic vs. pandemic semesters.

- Most classes used a scripting-based program for data analysis

	Pre-COVID (Sp19-F19)		COVID Online (Sp20 – Sp21)	
	n	%	n	%
Overall N	693		940	
Gender				
female	430	64%	594	68%
male	234	35%	273	31%
URM (Latinx, Black, Native American)				
no	512	74%	677	72%
yes	181	26%	263	28%
First Generation (FG)				
no	516	77%	650	75%
yes	150	23%	216	25%
Class size (mean)	23.9*		19.6*	
School Type				
liberal arts	396	57%	542	58%
flagship	91	13%	77	8.2%
regional & state	184	27%	264	28%
community college	22	3.2%	57	6.1%
Language				
click	113	16%	247	26%
script	580	84%	693	74%

Were student-reported outcomes of the PDS curriculum affected by transition to an online format during the pandemic?

No

Distributions of reported gains/outcomes are very similar over semester.

Red bar denotes the mean
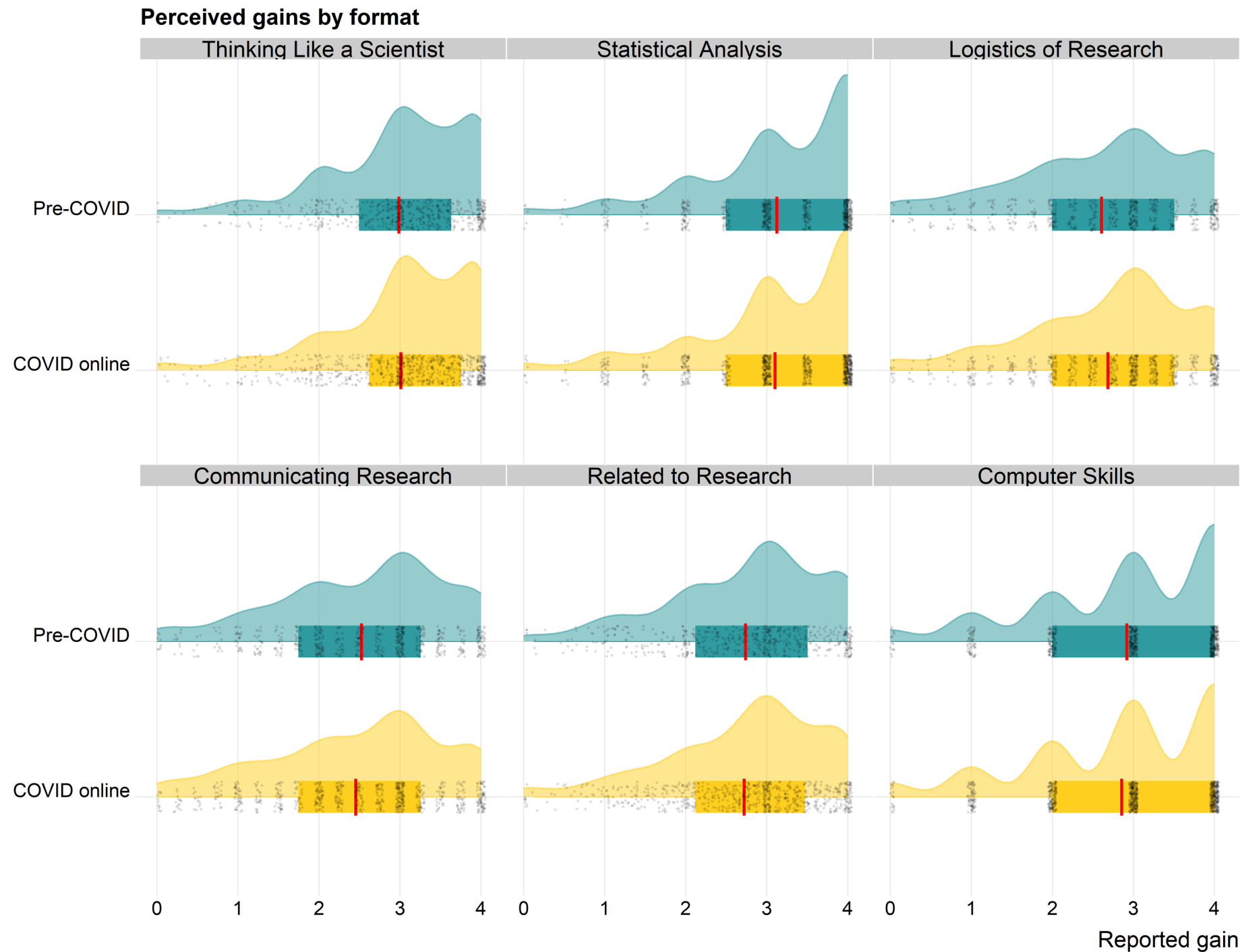
Perceived gains by format

Thinking Like a Scientist · Statistical Analysis · Logistics of Research · Communicating Research · Related to Research · Computer Skills

Pre-COVID / COVID online

Reported gain

Were student-reported outcomes of the PDS curriculum affected by transition to an online format during the pandemic?

Very small, and not statistically significant differences were seen in the average reported gains from pre-covid (S19-F19) to Covid online (S20-S21)

Average marginal effect of format on gains

Thinking Like a Scientist — 0.04 (-0.05,0.13)

Statistical Analysis — 0.02 (-0.08,0.12)

Related to Research — 0.01 (-0.09,0.11)

Logistics of Research — 0.06 (-0.05,0.17)

Communicating Research — -0.06 (-0.17,0.05)

Difference in marginal means (Covid online - Pre-Covid)

Average marginal effect of format on gains
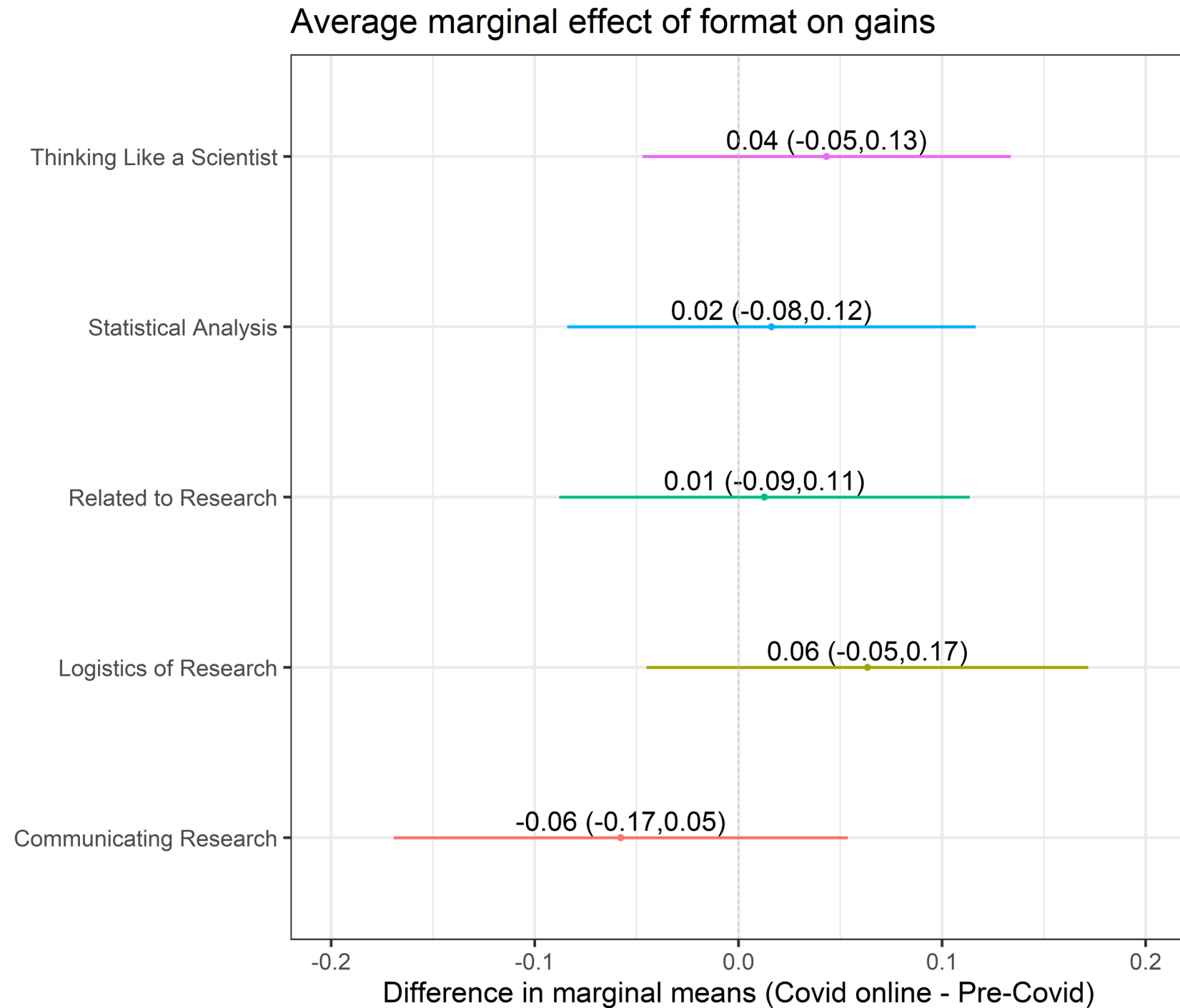
Were first generation or under-represented minorities differentially affected by the change in format?

No

No statistically significant changes.

Non-URM First generation students consistently reported lower gains during online learning compared to other groups.

Less variability in experience for historically traditional students? Could also be due to sample size.

Gain
- Communicating Research
- Logistics of Research
- Related to Research
- Statistical Analysis
- Thinking Like a Scientist

Difference in marginal means (Covid online - Pre-Covid)
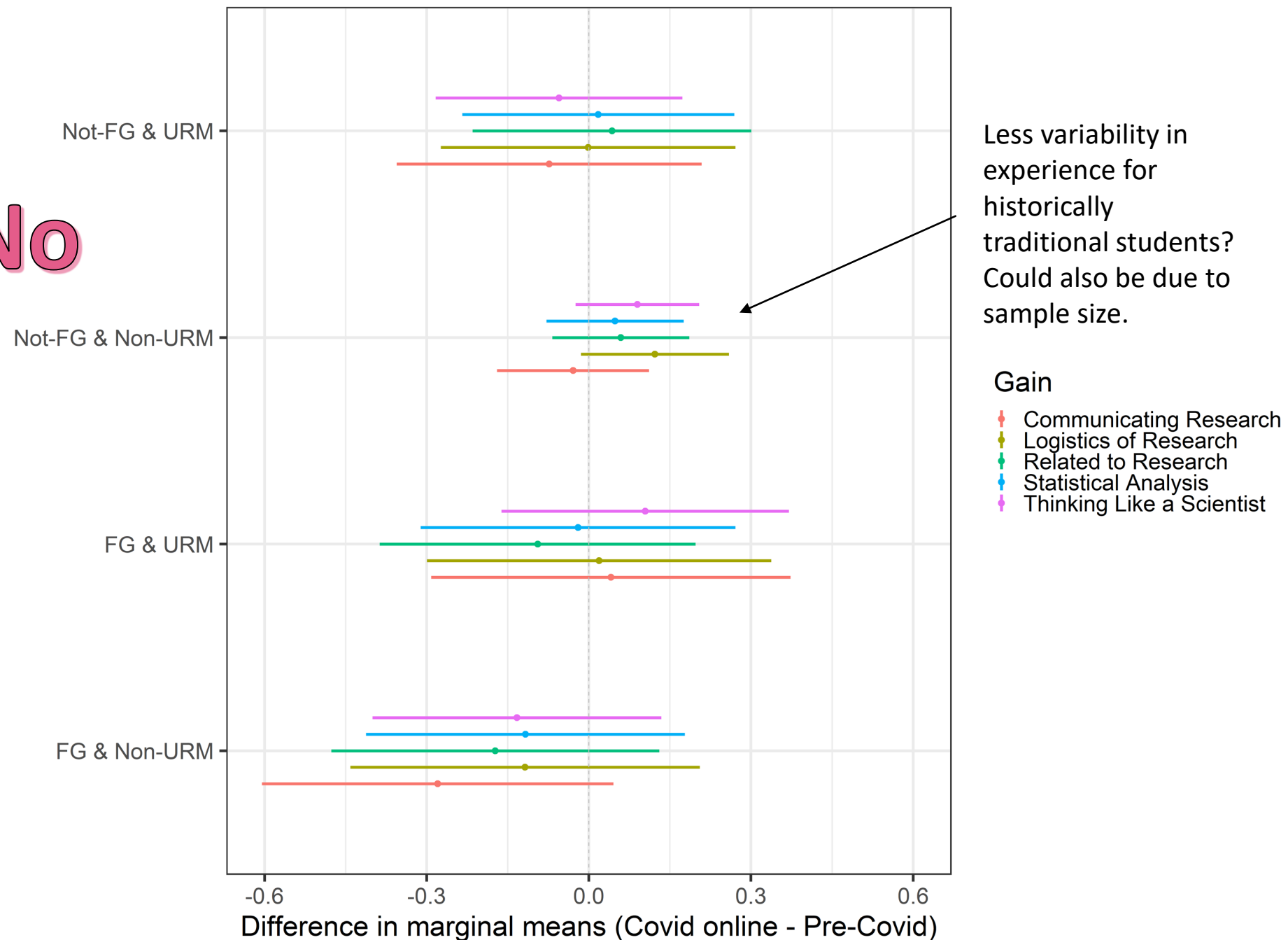
IMPLICATIONS

The PDS curriculum demonstrates resilience and flexibility in transitioning to an online format

PDS shows equity in learning outcomes for students who are from under-represented minorities and underserved groups

On average, students report positive gains and increased interest in future research or statistics

Effective strategies for teaching statistics, especially in an online environment, helps improve learning outcomes in STEM education for all student types
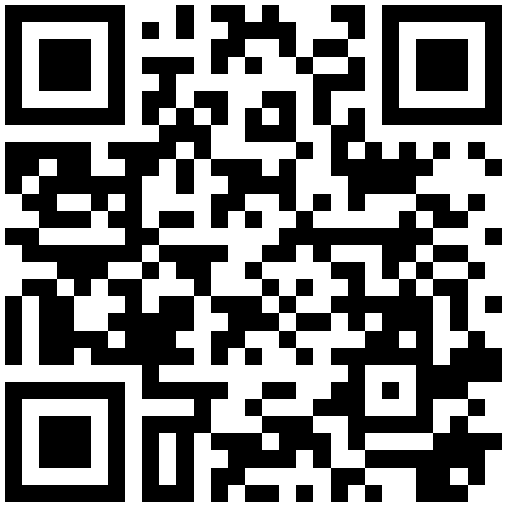
FURTHER AREAS TO BE EXPLORED

Matched pre-post changes in interests in future research & statistics courses

Changes in student engagement between pandemic and pre-pandemic semesters

SCAN TO LEARN MORE
ABOUT THE PDS MODEL

Q&A

EXAMPLE SURVEY QUESTIONS

Construct	Question
Thinking like a scientist	How much did you GAIN in formulating a research question that could be answered with data?
Work Related to Research	How much did you GAIN in comfort in working collaboratively with others?
Communication	How much did you GAIN in making oral presentations?
Statistical Analysis	How much did you GAIN in using statistics to analyze data?
Logistics of Conducting Research	How much did you GAIN in managing your time?
Computer Skills	How much did you GAIN in working with computers?
Coding	How much did you GAIN in coding?

Class Engagement

How often did you...

- ask questions in class

- Discuss course grades or assignments with instructor

- Attend OH

- Tutor other students

- Prepare for class by completing assigned readings/ videos

- Review class material before it was covered

- Attend review or help sessions

- Study with students from the course

- Participate in class discussions

DIFFERENCES ACROSS SCHOOL TYPE

	Private Liberal Arts		Flagship State		Regional & State		Community	
	n	%	n	%	n	%	n	%
Overall N	938		168		448		79	
Gender								
female	545	61%	95	57%	323	72%	61	77%
male	338	38%	64	38%	91	20%	14	18%
self-identify	7	0.8%	2	1.2%	4	1%	1	1%
missing	48		7		30		3	
URM								
no	783	83%	118	70%	251	56%	37	47%
yes	155	17%	50	30%	197	44%	42	53%
missing	0		0		0		0	
First Generation								
no	758	86%	111	70%	246	59%	51	69%
yes	125	14%	47	30%	171	41%	23	31%
missing	55		10		31		5	
Class size (# of respondents)								
	26*		28*		14*		8*	
Language								
click	175	19%	24	14%	125	28%	36	46%
script	763	81%	144	86%	323	72%	43	54%

*represented as the mean

PANDEMIC ONLINE LEARNING

- Few studies have directly compared learning outcomes between pre-pandemic and pandemic online learning

- Small but significant negative impact of pandemic distance learning on student performance and learning outcomes (-0.2 SD)

- Factors influencing student satisfaction and learning
  - Access to technology / technology literacy
  - Self-regulated learning skills
  - Instructor's prior online teaching experience
  - Interaction with instructor and peers
  - Student-to-school affiliation (or belonging)
  - Engagement
  - Environmental stressors
  - Course design

Barber (2021), Deng (2021), Igai (2022), Kofoed (2021), Orlov (2021), Morris (2021), Pennino (2022), Randazzo (2021)

EQUITY IN ONLINE-LEARNING

- Concern that emergency distance learning widened the equity gap in learning outcomes for traditionally marginalized and low-income students

- Student experience during the pandemic were heterogenous

- Underrepresented minority (URM), first-generation (FG), low-income students report increased challenges

  - demands to care for siblings

  - reduced access to reliable technology

  - increased financial stressors

- Mixed findings as to whether learning outcomes differed

Barber (2021); Keibler (2021), Morris (2021), Orlov (2022), Tate (2022)

THE STUDENT EXPERIENCE IN INTRODUCTORY STATISTICS

Students often believe statistics class will be a negative experience

Less likely to pursue related careers or apply statistical reasoning to evidence-based practices

Engagement and satisfaction are critical to the pursuit of STEM careers and educated decision-makers

Project-based learning shown to increase student engagement and promotes "deep-learning" (or knowledge-in-use)

(Cobb, 2007; Koparan, 2014; Miller, 2019; Onwuegbuzie, 1997; Petocz & Reid, 2005)