TIP: Infusing Data-Centered Pedagogy and Data-Analytical Skills into Introductory Statistics

Sayed Mostafa & Tamer Elbayoumi

I. Introduction

Background

- Nolan and Temple Lang's (2010) paper on "Computing in the Statistics Curriculum" led many statistics educators to advocate integrating computing in statistics courses starting with the Introductory Statistics (Intro Stats) course.
- The need for a computationally-infused statistics curriculum was further signified by the fast-growing demands on graduates with computational and data analytical skills who can work as data scientists.
- See the *Journal of Statistics & Data Science Education Special Issue on* "Integrating computing in the statistics and data science curriculum: Creative structures, novel skills and habits, and ways to teach computational thinking" [2].

Objectives

We aim to

1. introduce an Intro Stats course design that integrates computing as a core component of the course and
2. evaluate the effectiveness of such design for
   - enhancing students' statistical gains,
   - boosting students' levels of data science (DS) awareness, aspiration, and readiness, and
   - improving students' overall course performance.

II. Computationally-Infused Intro Stats

Figure 1 – Proposed Intro Stats Course Design – Phase I (Fall 2022)

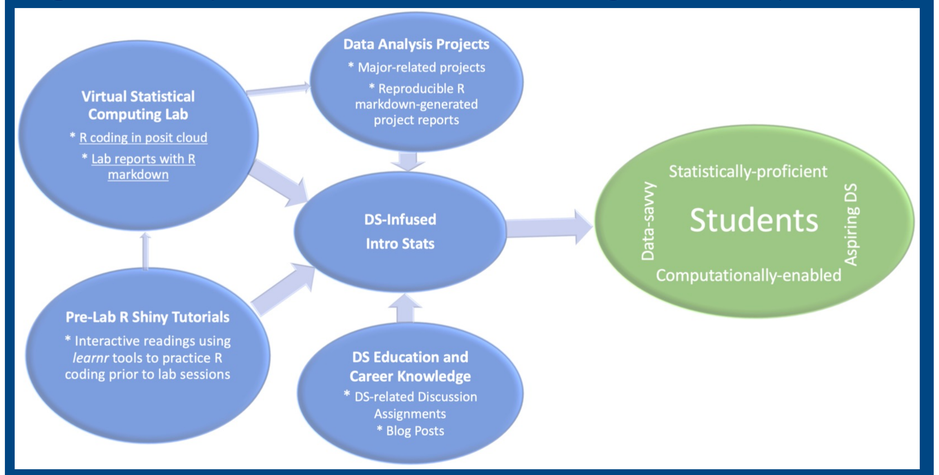
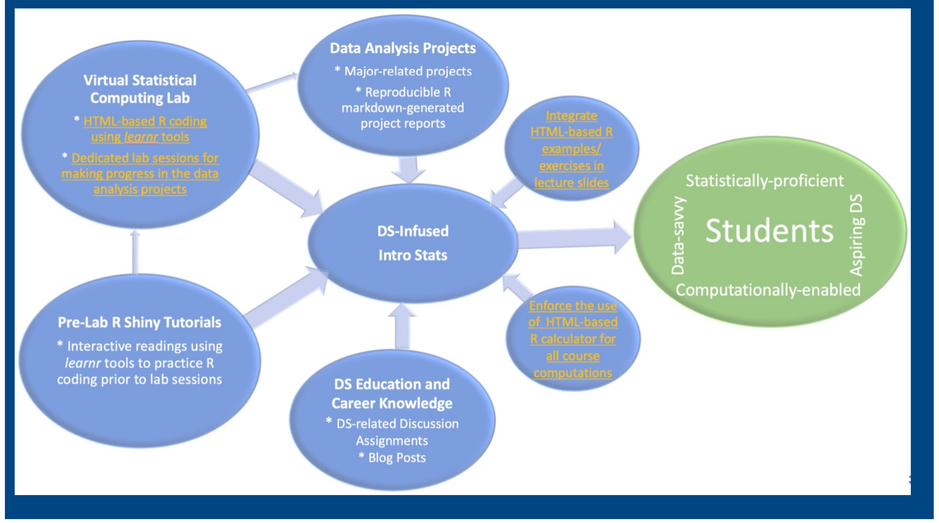


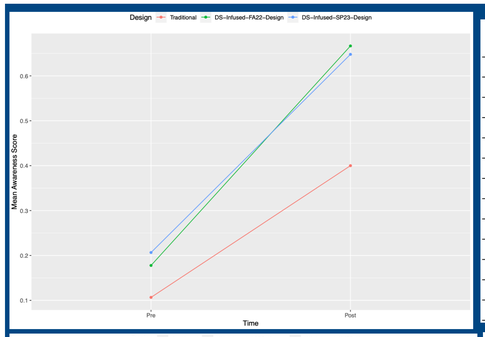
Figure 2 – Proposed Intro Stats Course Design – Phase II (Spring 2023)

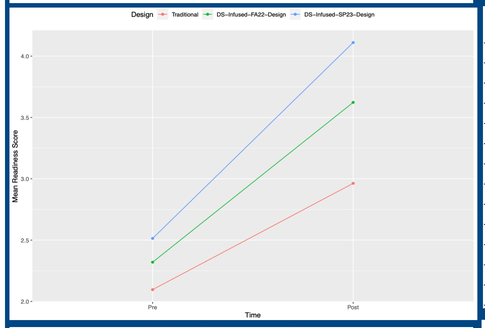


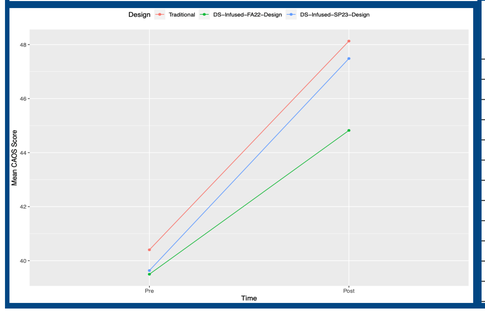
III. Methods

- **DS awareness, readiness & aspirations survey**
  - Students completed a DS awareness, readiness, and aspirations survey in Qualtrics (pre-survey and post-survey)
- **Statistical learning gains**
  - Students completed a revised version of the CAOS (Comprehensive Assessment of Outcomes in Statistics) scale [pre-test and post-test]
- **Overall performance**
  - Measured by final course grade (focus on DFW rate)

IV. Preliminary Results







▶ Gains in DS awareness: regression on course design

Regression Term	Estimate	LCL	UCL	p.value	Sig.
Intercept	0.43	-0.13	0.99	0.1301	Not Sig.
Type: DS-Infused-FA22-Design	0.26	0.08	0.44	0.0050	**
Type: DS-Infused-SP23-Design	0.18	0.02	0.33	0.0230	_*
Sex: Male	-0.09	-0.24	0.06	0.2439	Not Sig.
Race: Not Black	-0.14	-0.32	0.04	0.1225	Not Sig.
PELL Recepient: Yes	-0.21	-0.40	-0.02	0.0290	_*
Rural: Yes	0.11	-0.10	0.32	0.3135	Not Sig.
Residency: Out-of-State	0.05	-0.11	0.21	0.5109	Not Sig.
STEM: Yes	-0.15	-0.29	0.00	0.0431	_*
AP Stat: Yes	0.09	-0.07	0.25	0.2813	Not Sig.
Pre-Course Cum GPA	0.00	-0.14	0.14	0.9858	Not Sig.
Attendance	0.00	0.00	0.01	0.6380	Not Sig.

▶ Gains in DS readiness: regression on course design

Regression Term	Estimate	LCL	UCL	p.value	Sig.
Intercept	0.94	-0.53	2.42	0.2087	Not Sig.
Type: DS-Infused-FA22-Design	0.43	-0.04	0.90	0.0740	Not Sig.
Type: DS-Infused-SP23-Design	0.84	0.46	1.22	0.0000	****
Sex: Male	-0.16	-0.54	0.22	0.4079	Not Sig.
Race: Not Black	-0.21	-0.67	0.25	0.3687	Not Sig.
PELL Recepient: Yes	-0.62	-1.11	-0.13	0.0130	_*
Rural: Yes	-0.58	-1.10	-0.06	0.0296	_*
Residency: Out-of-State	0.30	-0.09	0.70	0.1300	Not Sig.
STEM: Yes	-0.06	-0.44	0.32	0.7428	Not Sig.
AP Stat: Yes	-0.27	-0.68	0.14	0.1934	Not Sig.
Pre-Course Cum GPA	0.15	-0.19	0.49	0.3932	Not Sig.
Attendance	0.00	-0.01	0.01	0.9119	Not Sig.

▶ Statistical learning gains (Change): regression on course design

Regression Term	Estimate	LCL	UCL	p.value	Sig.
Intercept	0.25	-19.37	19.87	0.9800	Not Sig.
Type: DS-Infused-FA22-Design	-0.82	-7.34	5.70	0.8049	Not Sig.
Type: DS-Infused-SP23-Design	0.28	-5.08	5.65	0.9172	Not Sig.
Sex: Male	-1.54	-6.46	3.37	0.5373	Not Sig.
Race: Not Black	1.15	-5.53	7.84	0.7340	Not Sig.
PELL Recepient: Yes	0.69	-5.52	6.89	0.8277	Not Sig.
Rural: Yes	-5.74	-12.38	0.90	0.0901	Not Sig.
Residency: Out-of-State	-6.29	-11.71	-0.88	0.0229	-*
STEM: Yes	1.14	-3.68	5.95	0.6422	Not Sig.
Pre-Course Cum GPA	-1.96	-6.69	2.76	0.4139	Not Sig.
Attendance	0.18	0.01	0.36	0.0408	-*

V. Conclusions

- Infusing computation and DS tools/knowledge into Intro Stats was associated with
  - significant gains in students' levels of awareness of and readiness for Statistics/DS education opportunities
  - modest statistical learning gains (to be confirmed by further data collection)
  - substantial improvement in the course success rate
- Infusing computation and DS tools/knowledge into Intro Stats seemed to drive some students away from aspiring for further DS education
  - in line with other findings in the literature that hinted at the complexity of computing and the challenges of integrating computing into intro courses [3]

VI. References

1. Nolan, D., and Temple Lang, D. (2010). Computing in the statistics curricula. *The American Statistician*, 64, 97–107.
2. Horton, N.J. and Hardin, J.S. (2021). Integrating computing in the statistics and data science curriculum: Creative structures, novel skills and habits, and ways to teach computational thinking. *Journal of Statistics and Data Science Education*, 29:sup1 S1-S3.
3. Woodard, V. and Lee, H. (2021). How students use statistical computing in problem-solving. *Journal of Statistics and Data Science Education* 29(1), 1– 18.

North Carolina Agricultural and Technical State University

NSF Targeted Infusion Project Grant #HRD2106945

North Carolina A&T State University
Department of Mathematics & Statistics
https://introtostatncat.github.io
sabdelmegeed@ncat.edu & tmelbayoumi@ncat.edu