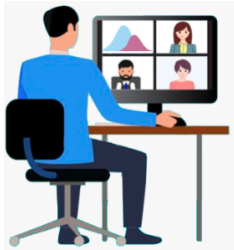

IASE 2021 Satellite Conference

Statistics Education in the Era of Data Science

Online conference 30 August – 4 September 2021

The Potential of Introductory Statistics to Promote Data Literacy and Attract Underrepresented Minority Students to Data Science

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North Carolina A&T State University

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Outline

- The Status of Intro Stats at NC A&T
  - Course design & content
  - Students gains from the course
  - GAISE recommendations in Intro Stats
- Data Science Awareness & Aspirations among Intro Stats Students
  - DS awareness & aspirations survey
  - The potential of Intro Stats to promote DS
- Redesigning Intro Stats to Promote DS

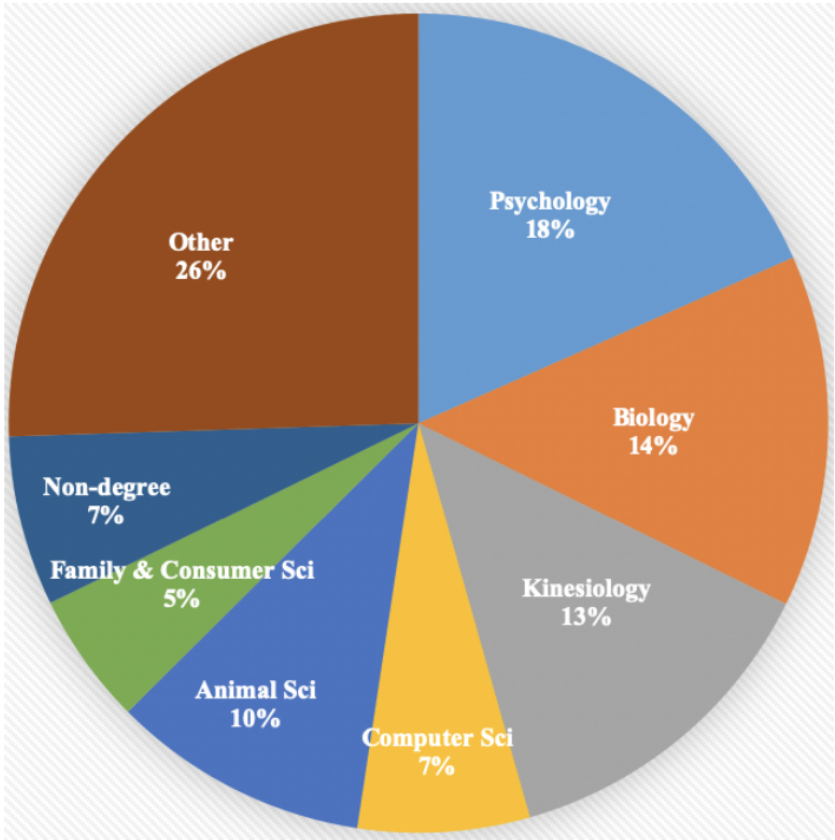
About NC A&T

NORTH CAROLINA AGRICULTURAL AND TECHNICAL STATE UNIVERSITY

- NC A&T is the largest Historically Black College and University (HBCU) in the United States
- Fall 2020 enrollment: over 12,000
- Top producer of Aferican American STEM graduates

Introductory Statistics at NC A&T

- "Introduction to Probability & Statistics" (MATH224)
- Algebra-based semi-coordinated 3.00 credits course
- Serves STEM (~46%) and non-STEM (~54%) majors



- About 7 sections (~45 students in each section) each semester

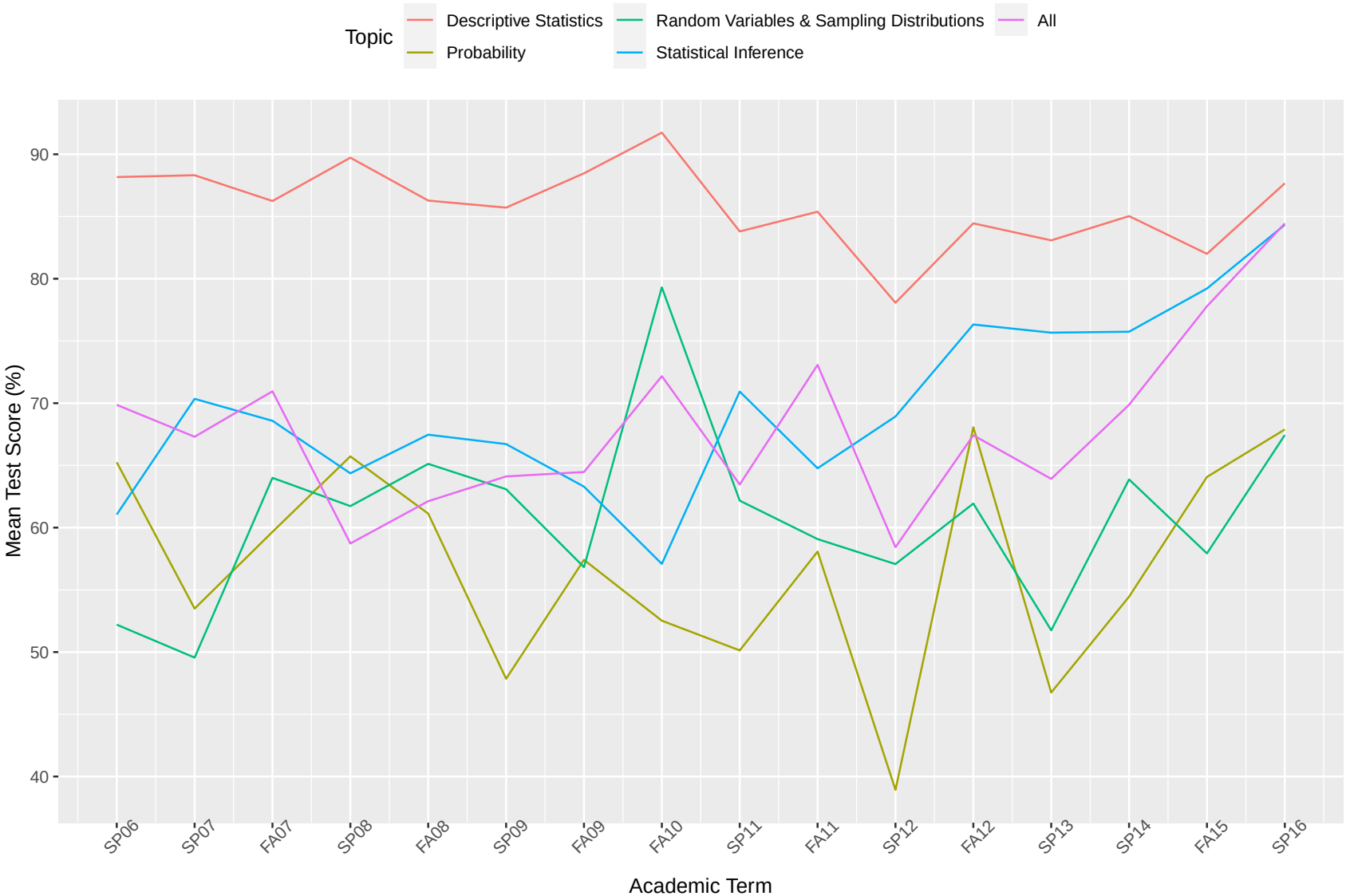
Introductory Statistics at NC A&T

- Course Design & Content:

Content and computation in the current Intro Stats course at NC A&T.	
1. Introduction (basic concepts) • Descriptive vs inferential statistics • Types of data (quantitative vs qualitative) • Sample vs population • Data collection & Sampling methods **2. Descriptive statistics** • Describing data graphically (manually/using excel construct various types of univariate graphs) • Numerical summaries (manually/using excel compute central tendency and variability measures, and standardized scores) • Bivariate relationships: scatterplots, correlation, and **simple linear regression*** **3. Introduction to probability** • Basic probability terminologies (sample spaces, events, complementary events, and unions and intersections of events) • Additive rule, disjoint events, multiplicative rule, independence and conditional probability	**4. Probability distributions** • Use formulas to compute expectation and variance of a given discrete probability distribution • Use binomial formula to compute probabilities about binary variables • Use normal table to compute probabilities and percentiles for normal random variables **5. Sampling distribution of sample mean** • Central limit theorem • Use normal table to compute probabilities about the sample mean/proportion **6. Confidence intervals** • Use formula, calculator and normal table or excel to compute confidence interval for the population mean/proportion **7. Hypothesis testing** • Perform 5 systematic steps and use calculator and normal table or excel to compute p-value and reject/retain the null hypothesis about the population mean/proportion

*Optional/time-permitting topic.

Students Performance in Intro Stats at NC A&T

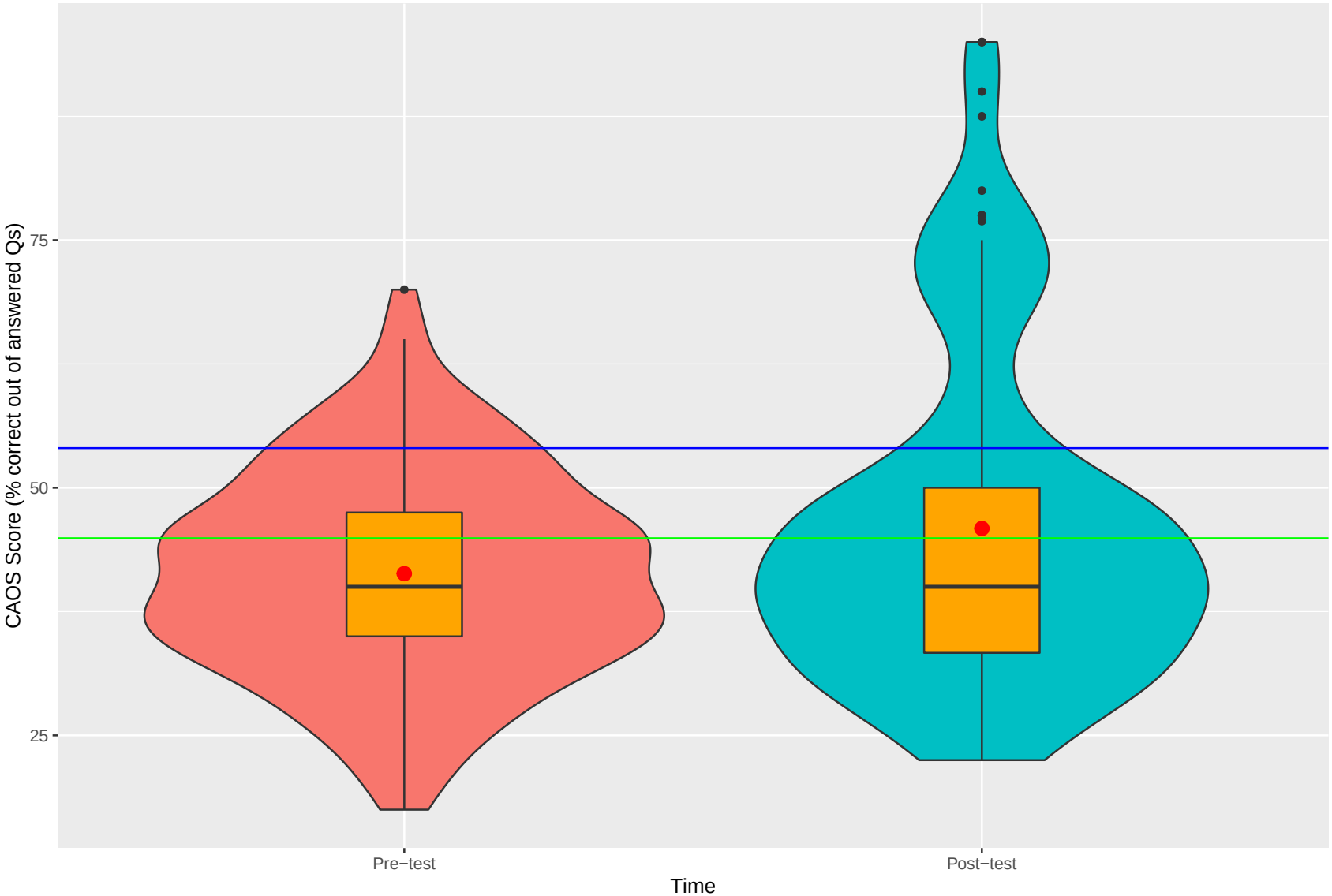


n ranges from 37 to 113 in different semesters

Students Learning Gains from Intro Stats

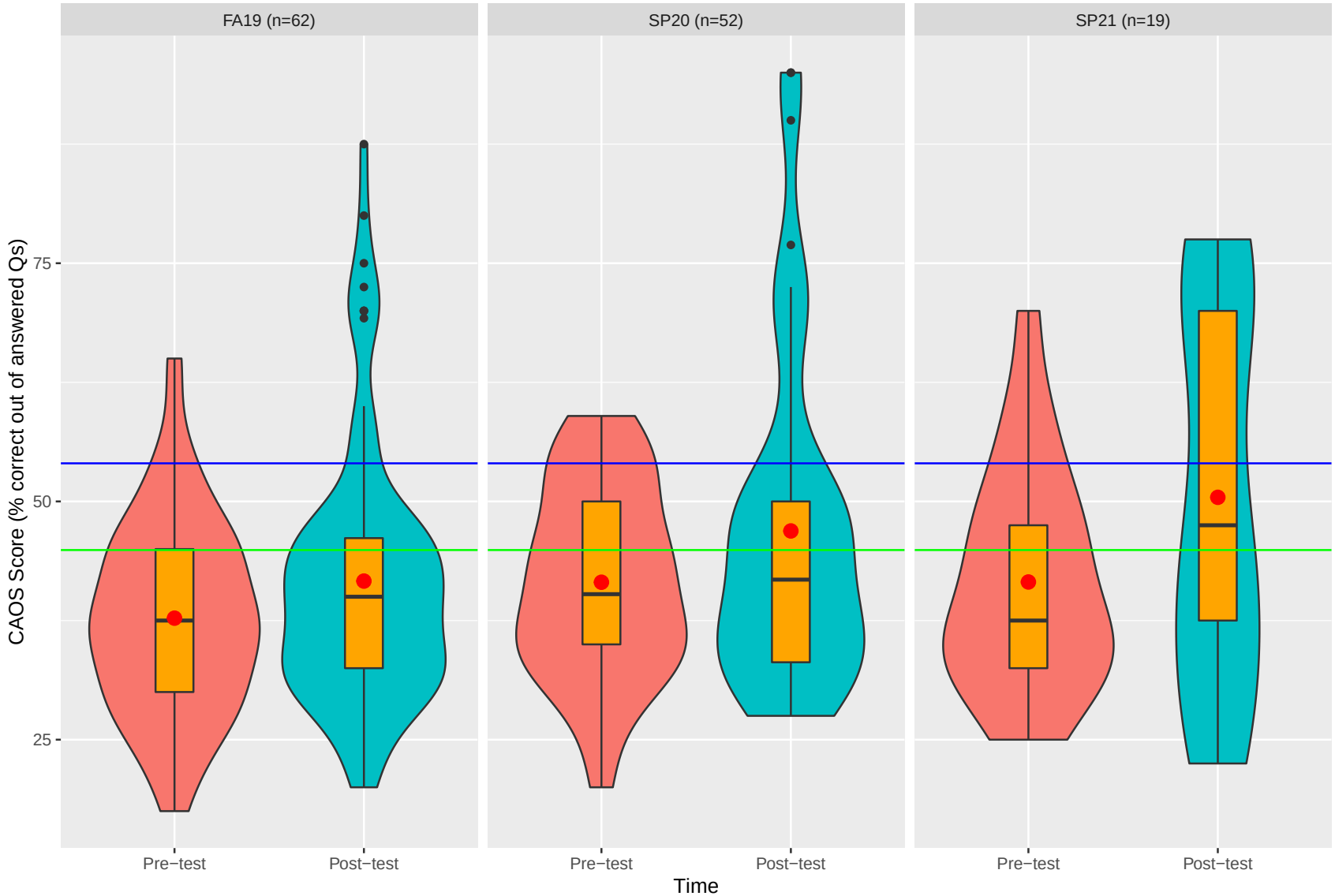
- The Comprehensive Assessment of Outcomes in Statistics (CAOS) test was used to measure students learning gains
- CAOS consists of 40 questions assessing concepts covered in the Intro Stats course (e.g., delMas et al., 2007)
- CAOS is commonly used for assessing students gains from Intro Stats (e.g., delMas et al. (2007); Tintle et al. (2018))
- Students in multiple sections of Intro Stats completed the test at the beginning and at the end of semester during Fall 2019, Spring 2020 and Spring 2021
- Students were encouraged to complete the pre- and post-test by offering some extra credit
- Student's response was considered valid if s/he completed both pre- and post-test and spent **between 10 to 60 minutes** on each test

Students Learning Gains from Intro Stats



n=133 ; Horizontal Lines = Pre/Post Test National Averages (delMas et al., 2007)

Students Learning Gains from Intro Stats



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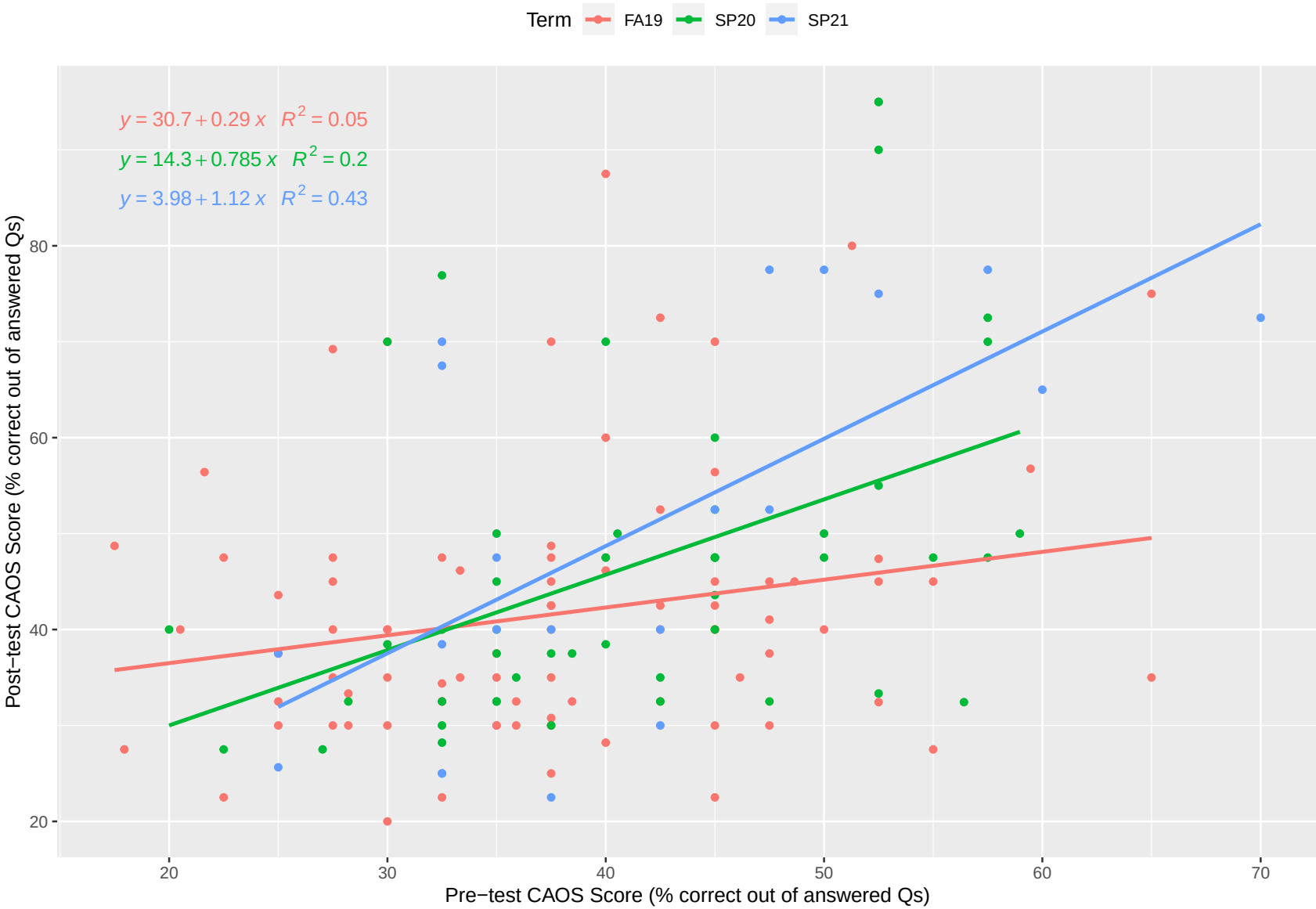
Students Learning Gains from Intro Stats



Data Science at NC A&T

- NCA&T offers several data science tracks to prepare students **from any major** to become data scientists:
  - **Undergraduate Certificate in Data Science & Analytics**
  - **Post-Baccalaureate Certificate in Data Analytics**
  - **MS in Data Science and Engineering**
  - **PhD in Data Science & Analytics**

Data Science at NC A&T

Undergraduate Certificate in Data Science & Analytics:

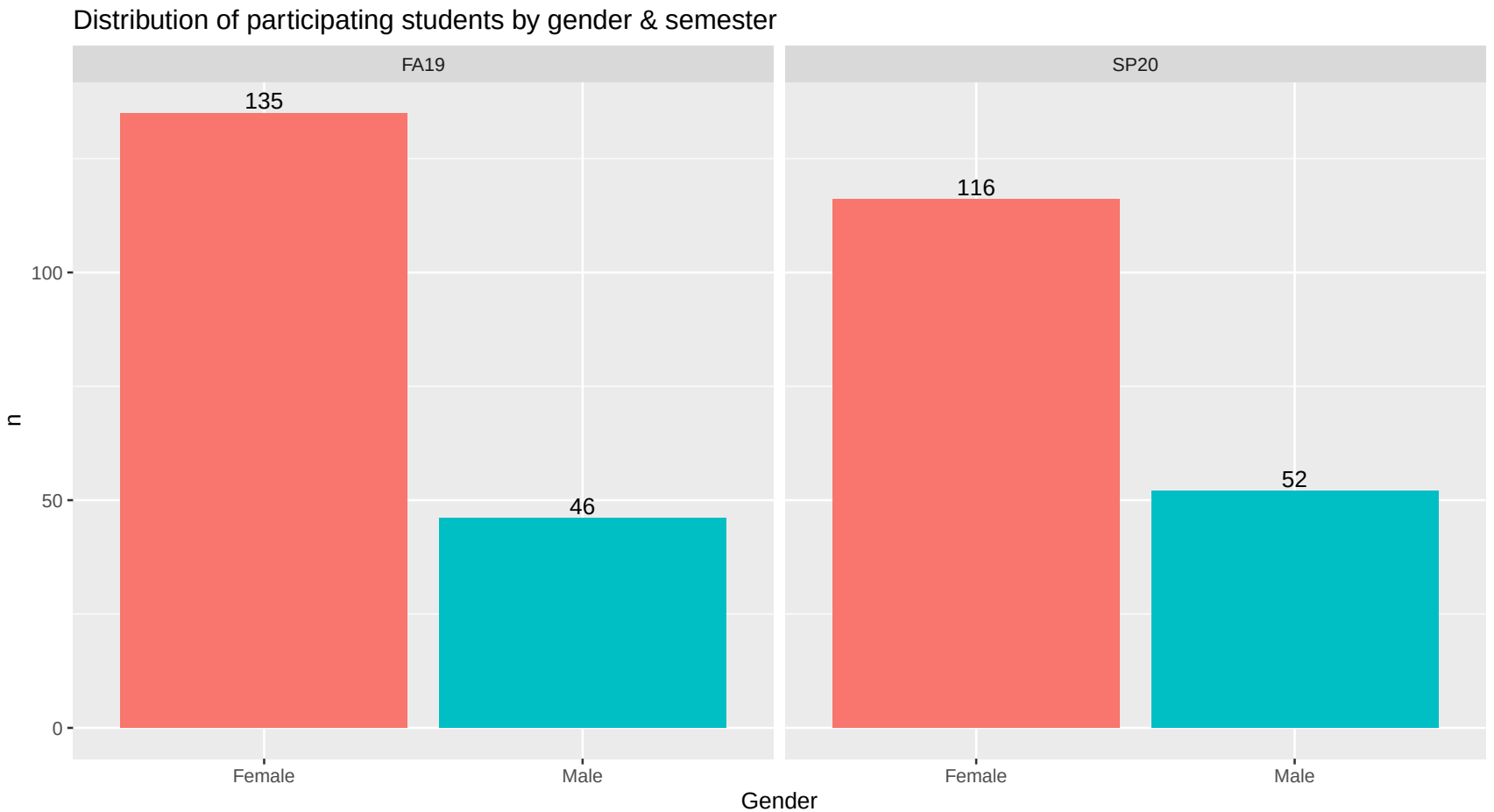
- Curriculum Requirements:

A student seeking the Undergraduate Certificate in Data Science and Analytics (DSA) must complete 15 credit hours of DSA-related undergraduate coursework:

- Two DSA core courses (6 credit hours): STAT 324 (Stat Methods for Data Analysis) and MATH 365 (Intro to Data Science) or COMP 365.
- Two DSA electives (6 credit hours): from STAT, BIOL, COMP, CST, ISEN, MGMT, or PHYS
- A DSA-related capstone project (3 credit hours).

NCA&T Students' Awareness of Data Science

- With DS being a relatively new field, most undergraduate students are unaware of the career opportunities it offers!!
- We surveyed the NC A&T Intro Stats students to collect data about their awareness and aspirations of DS.



NCA&T Students' Awareness of Data Science

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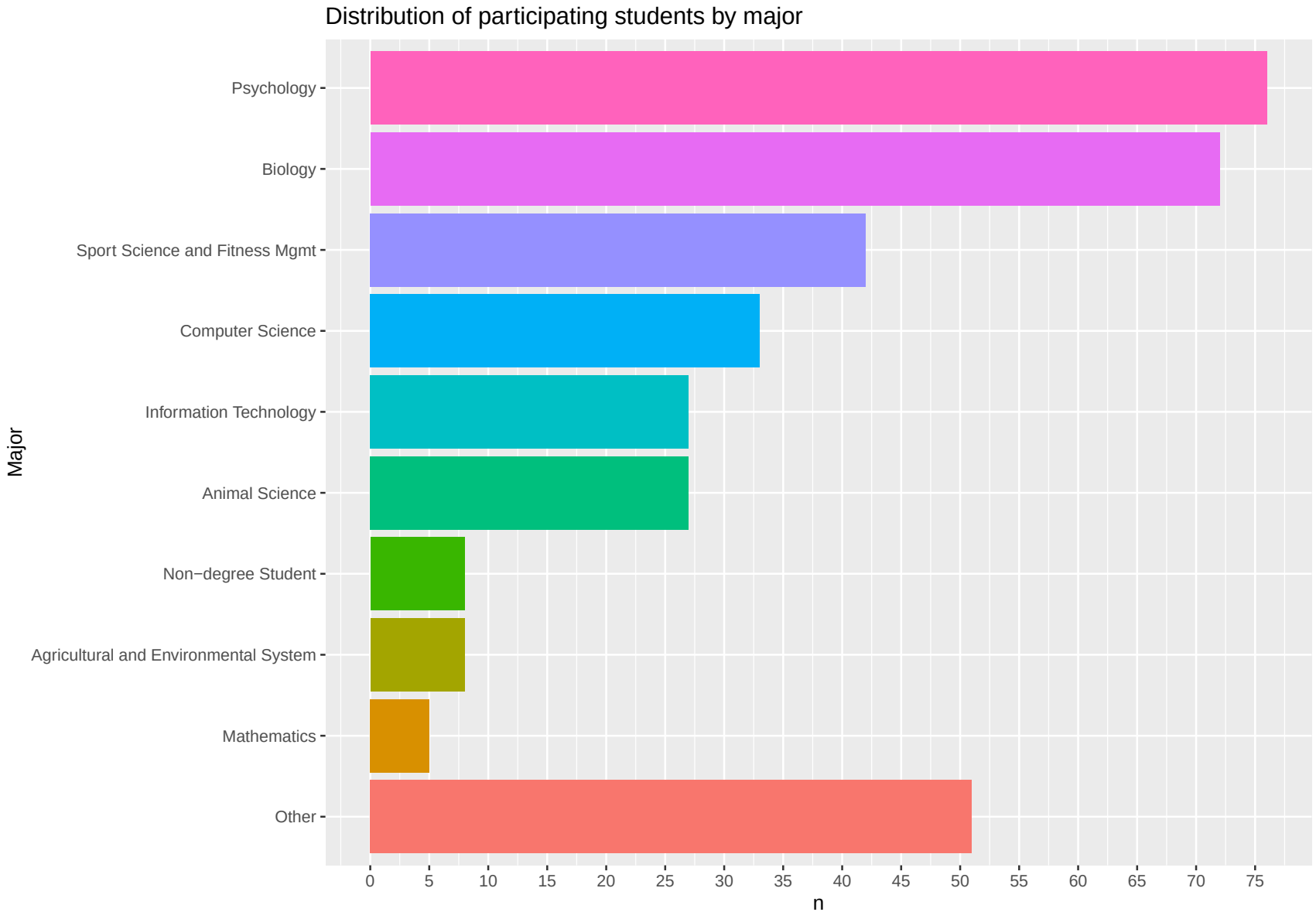
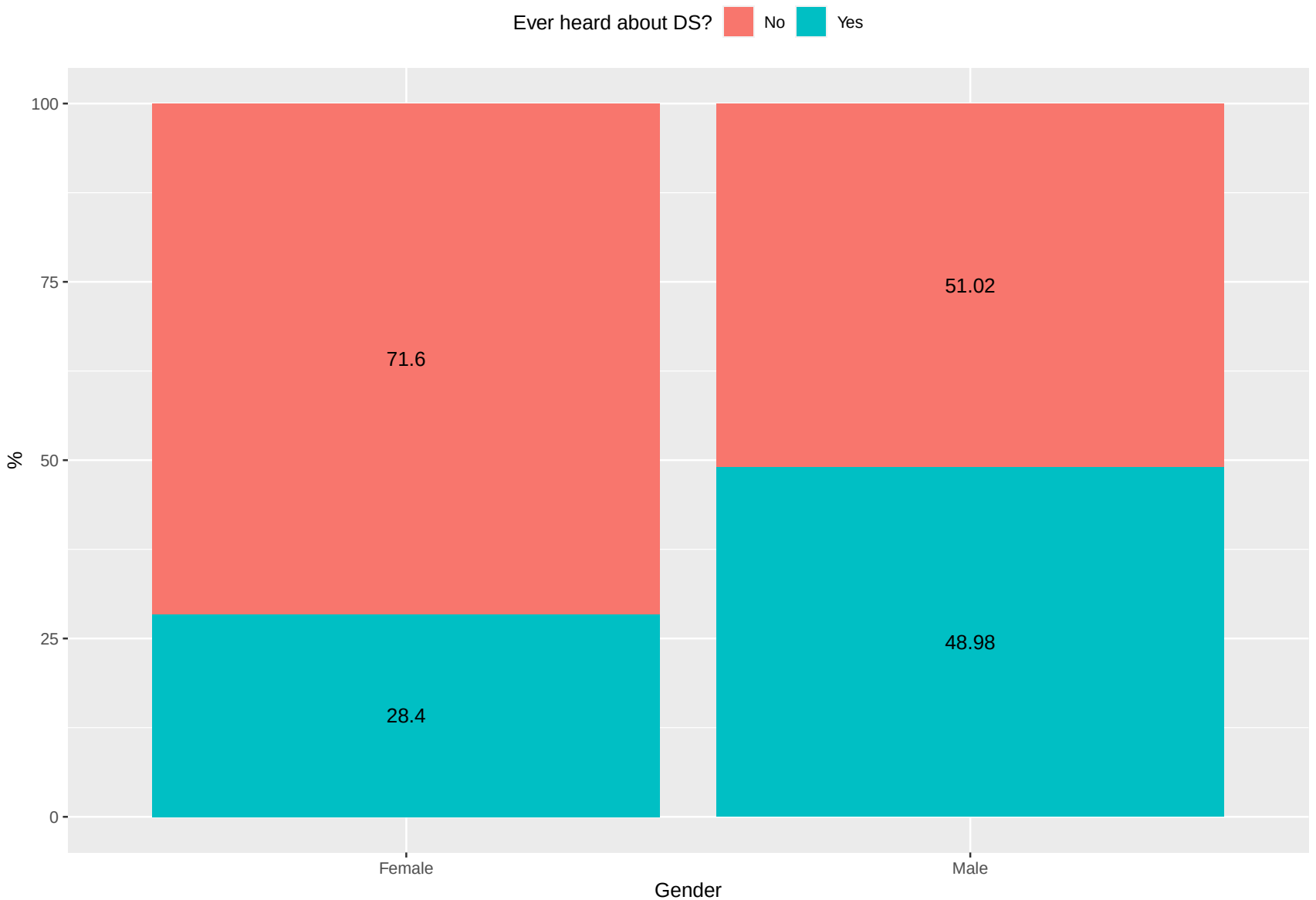
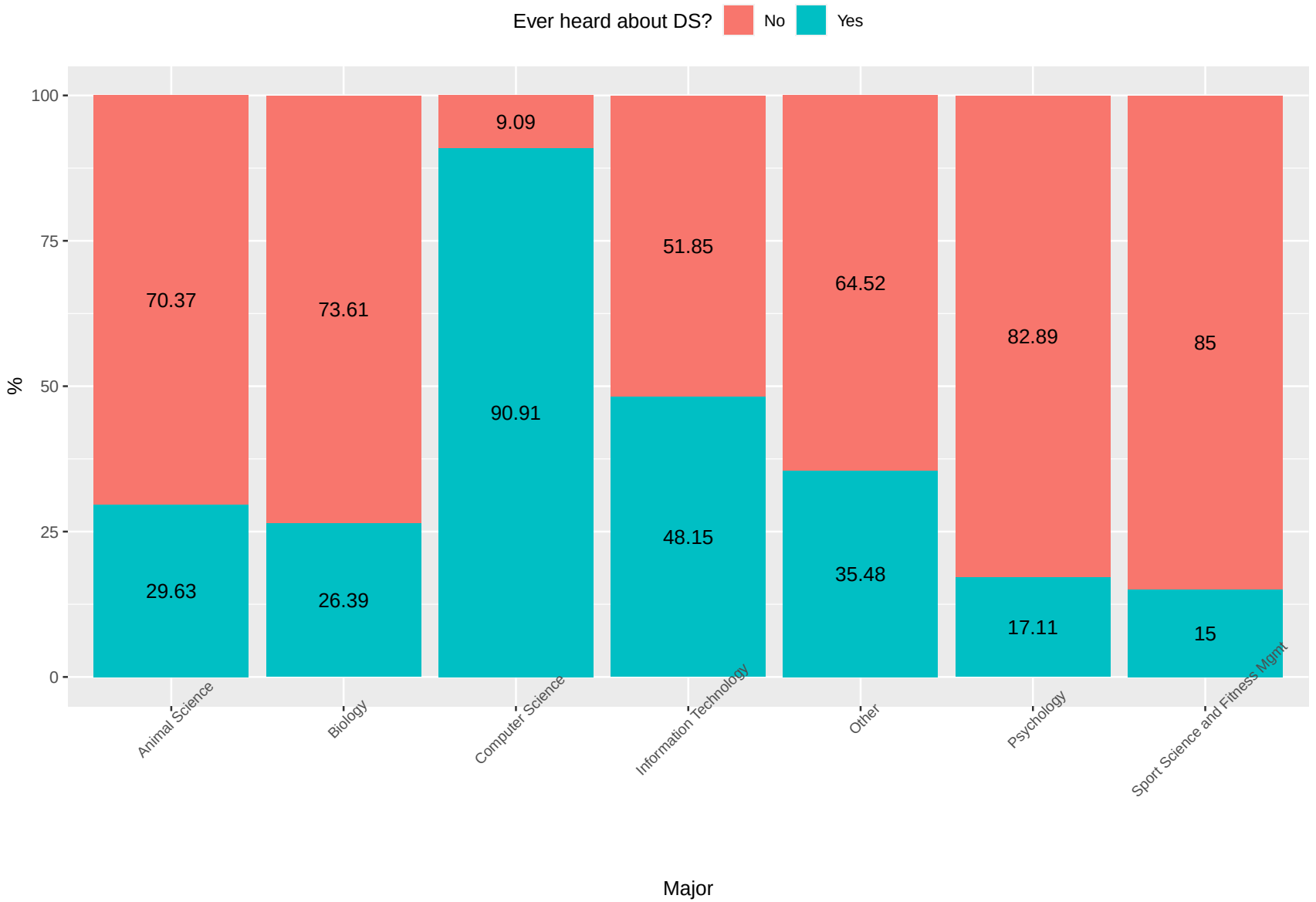


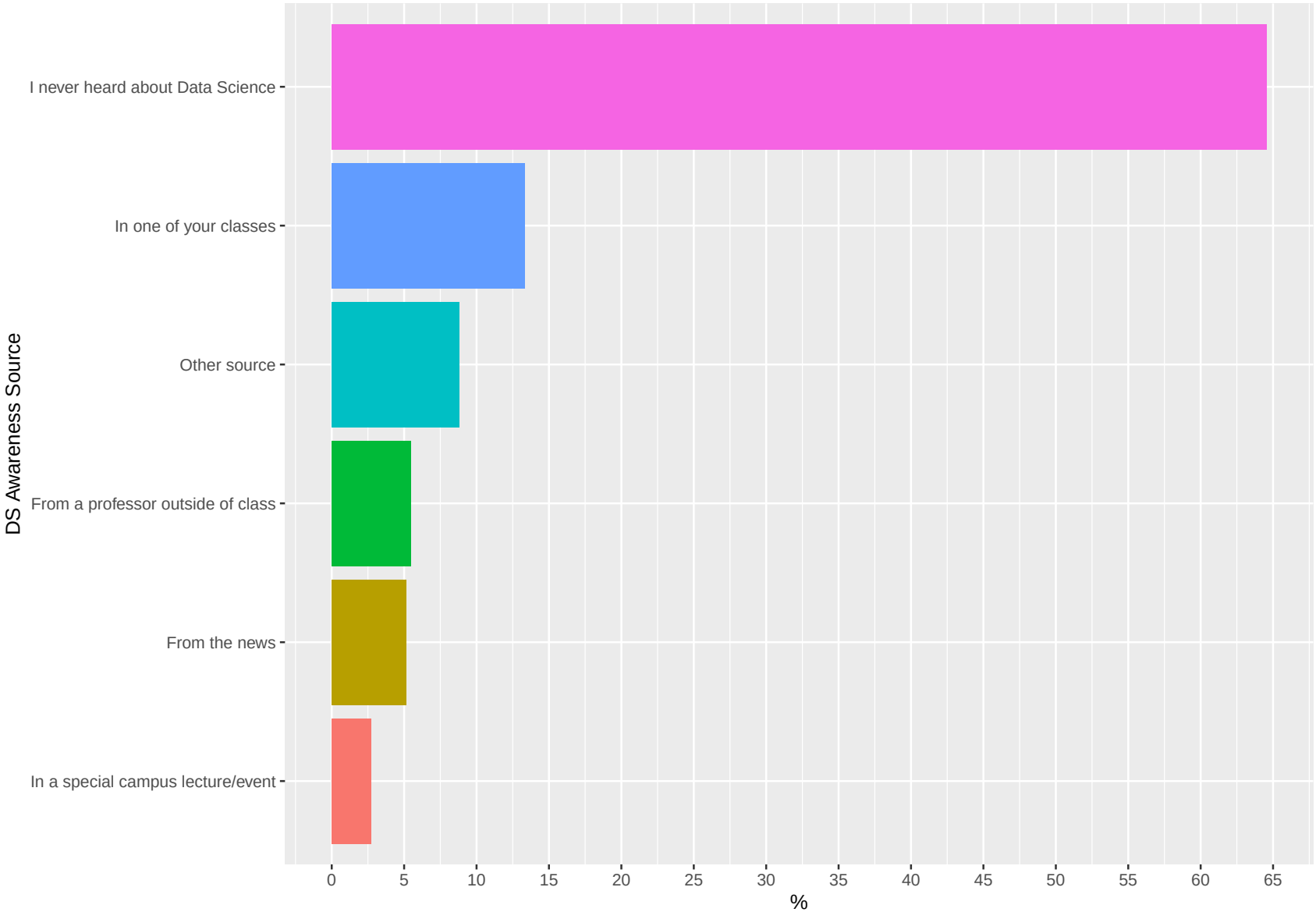
NCA&T Students' Awareness of Data Science by Gender



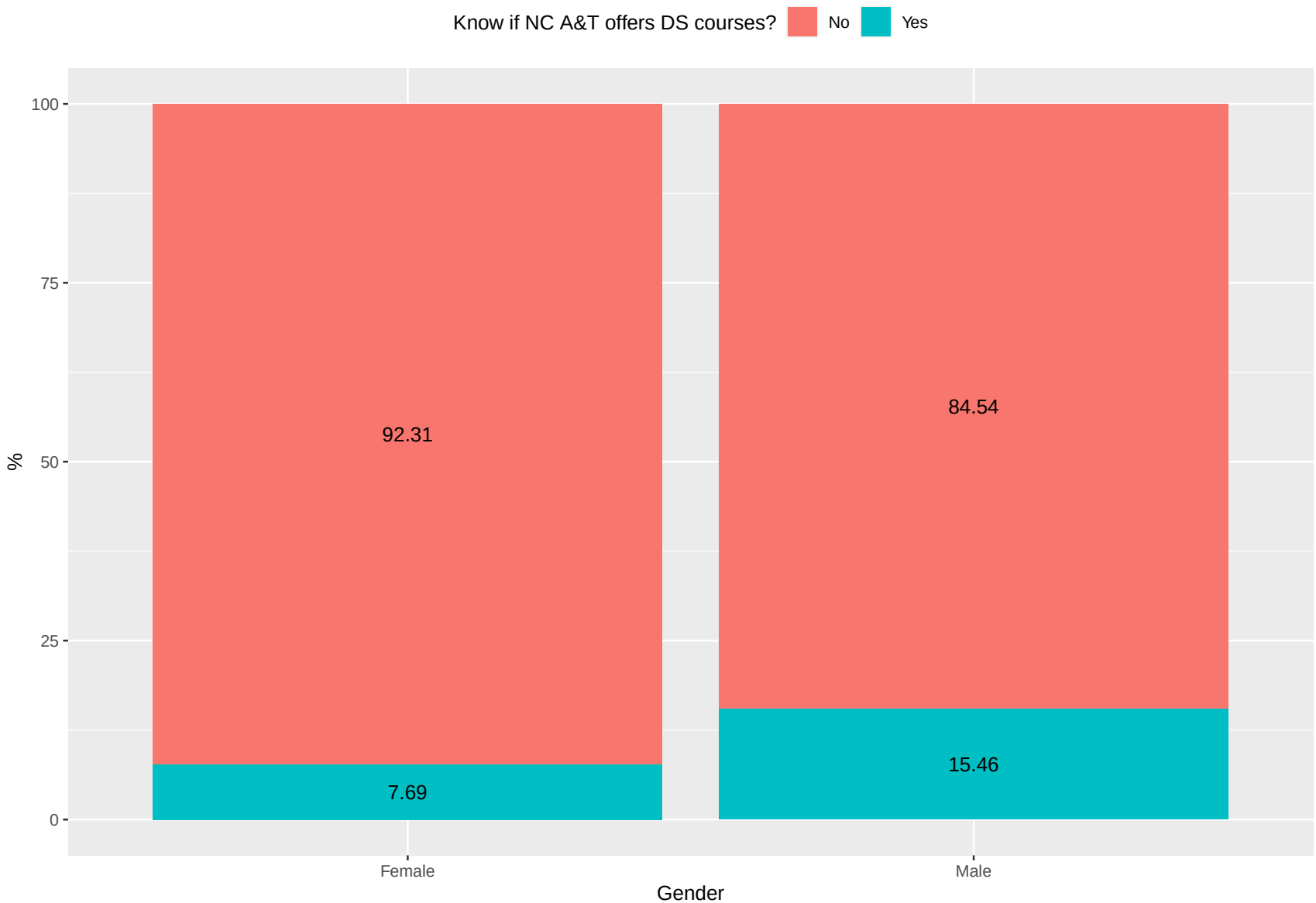
NCA&T Students' Awareness of Data Science by Major



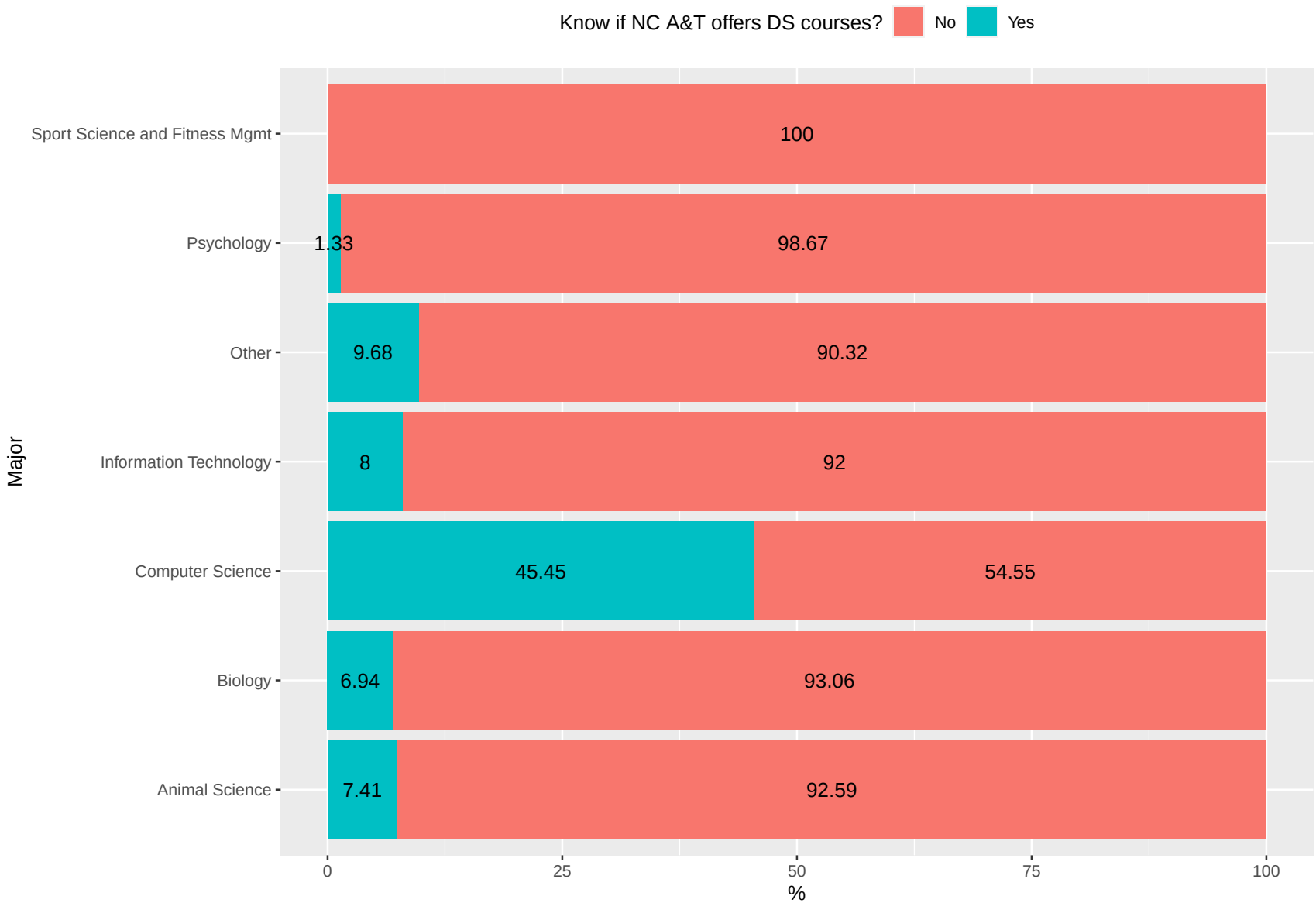
NCA&T Students' Awareness of Data Science by Source



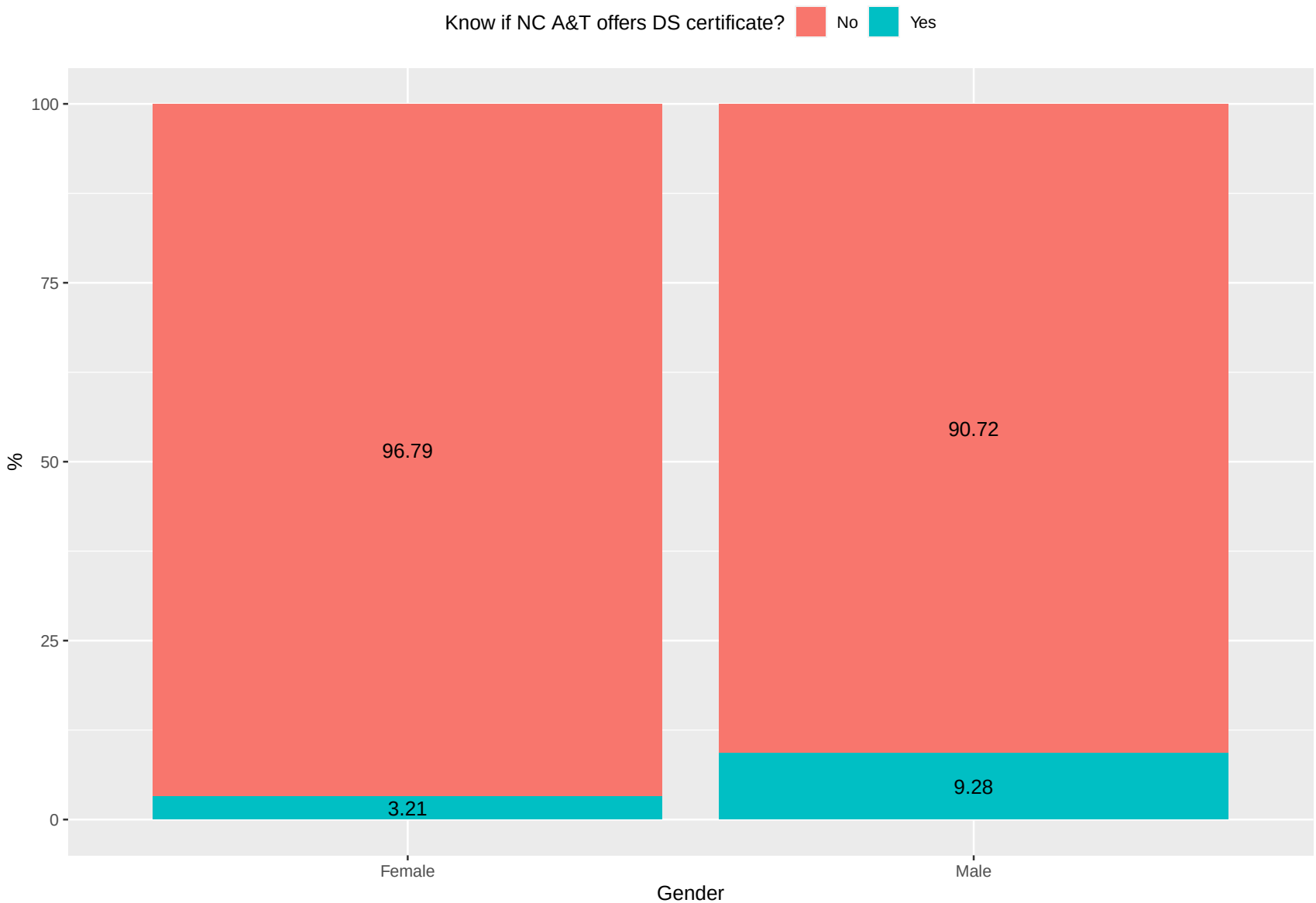
NCA&T Students' Awareness of Data Science



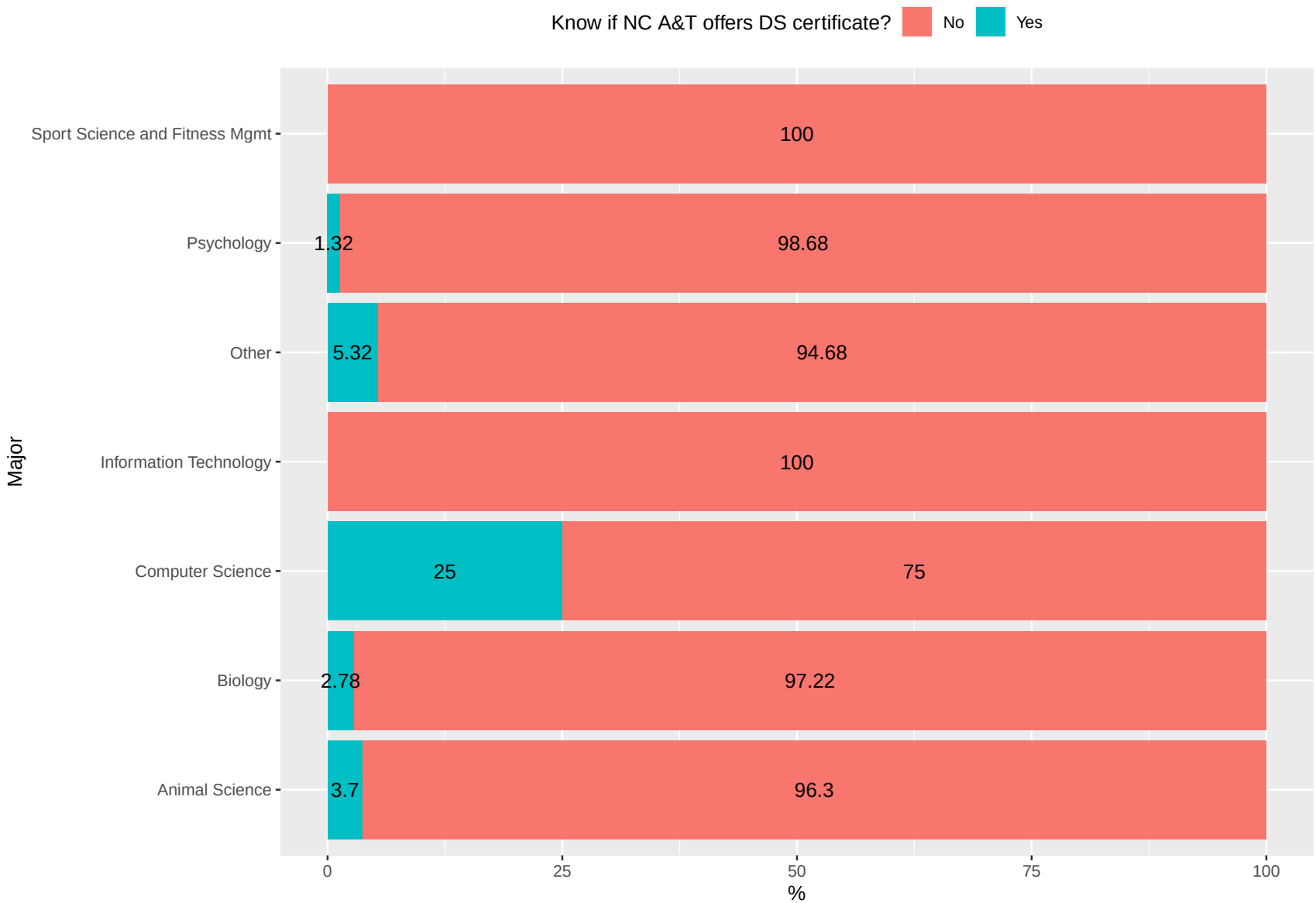
NCA&T Students' Awareness of Data Science



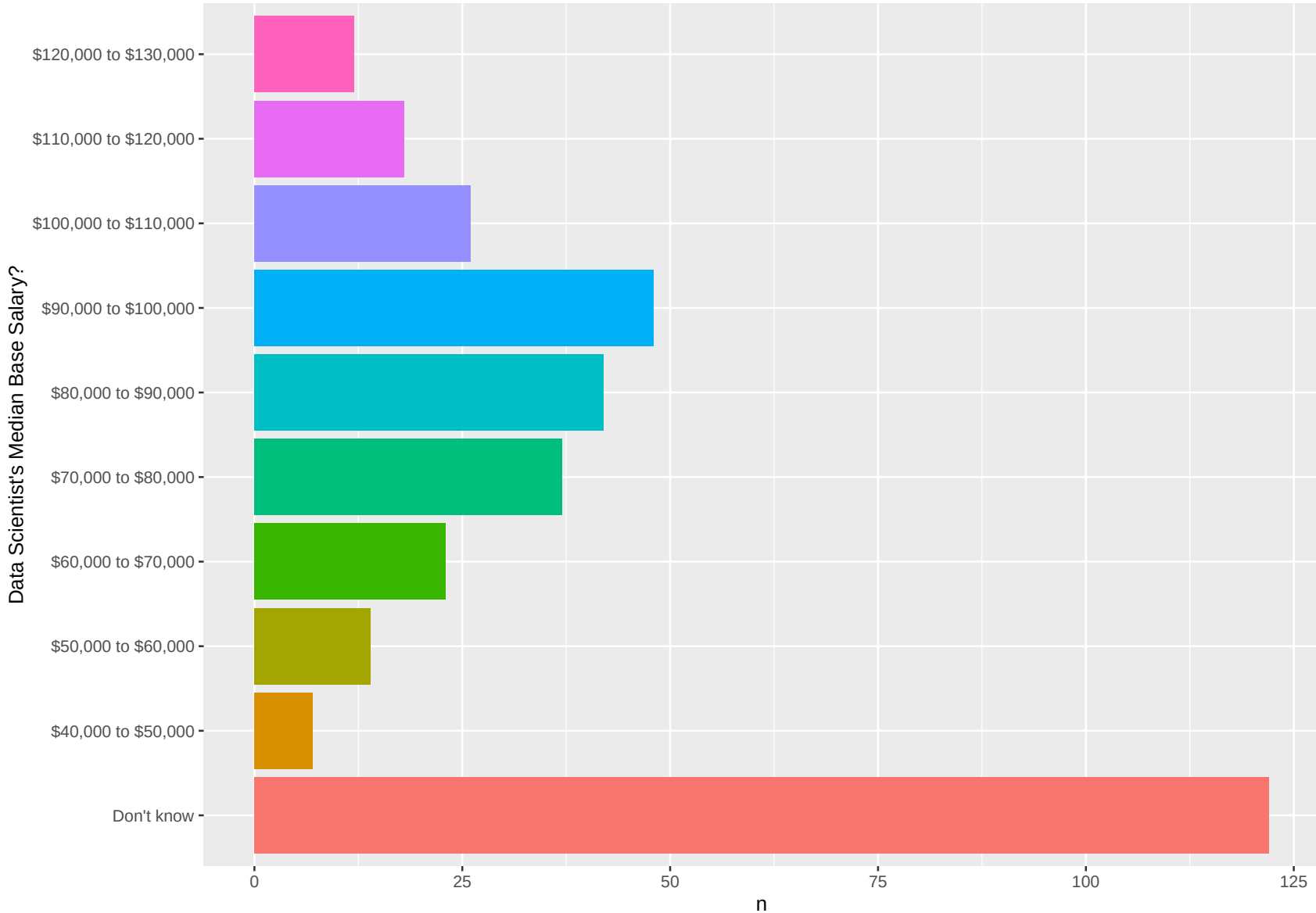
NCA&T Students' Awareness of Data Science



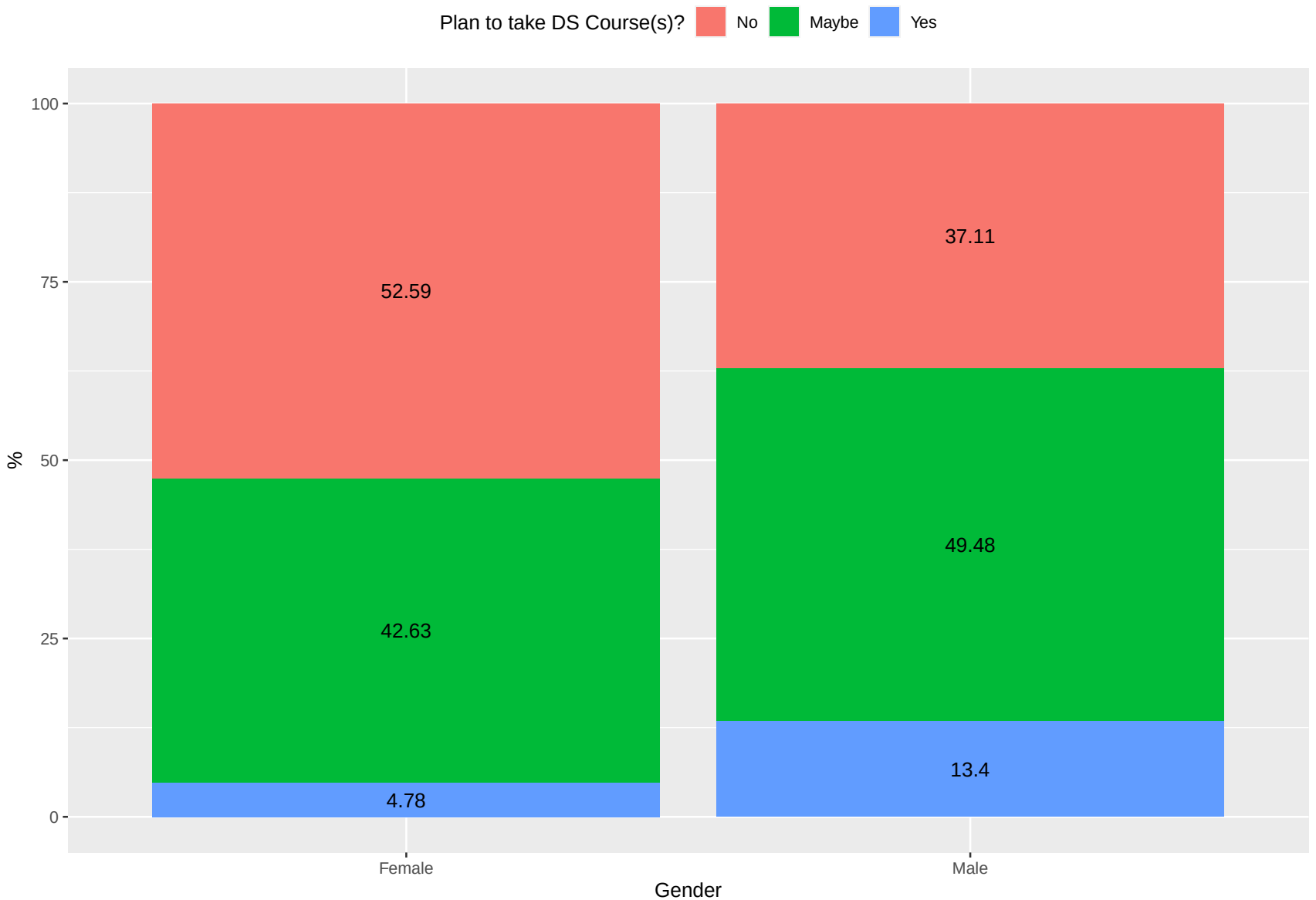
NCA&T Students' Awareness of Data Science



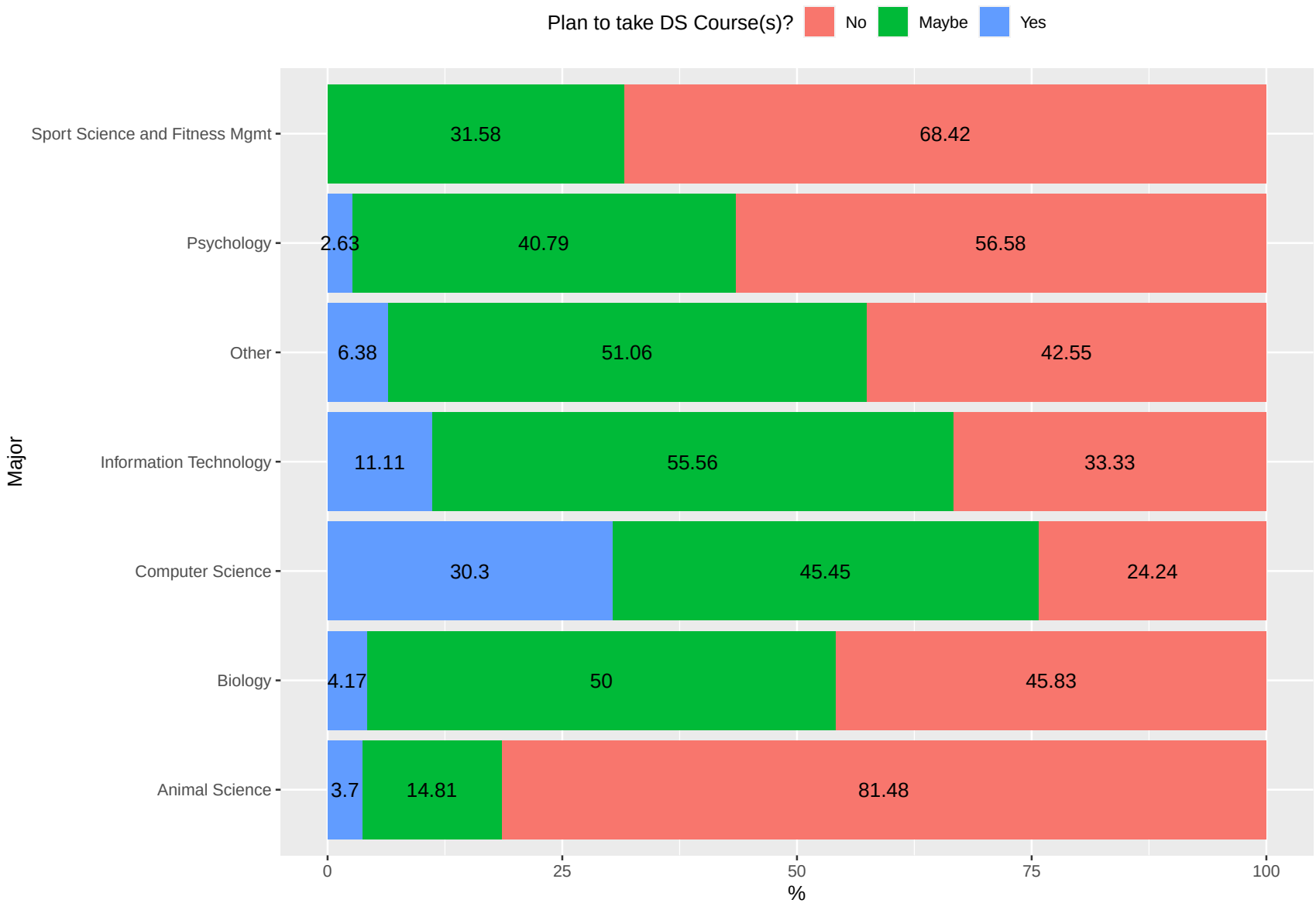
NCA&T Students' Awareness of Data Science



NCA&T Students' Aspirations of Data Science



NCA&T Students' Aspirations of Data Science



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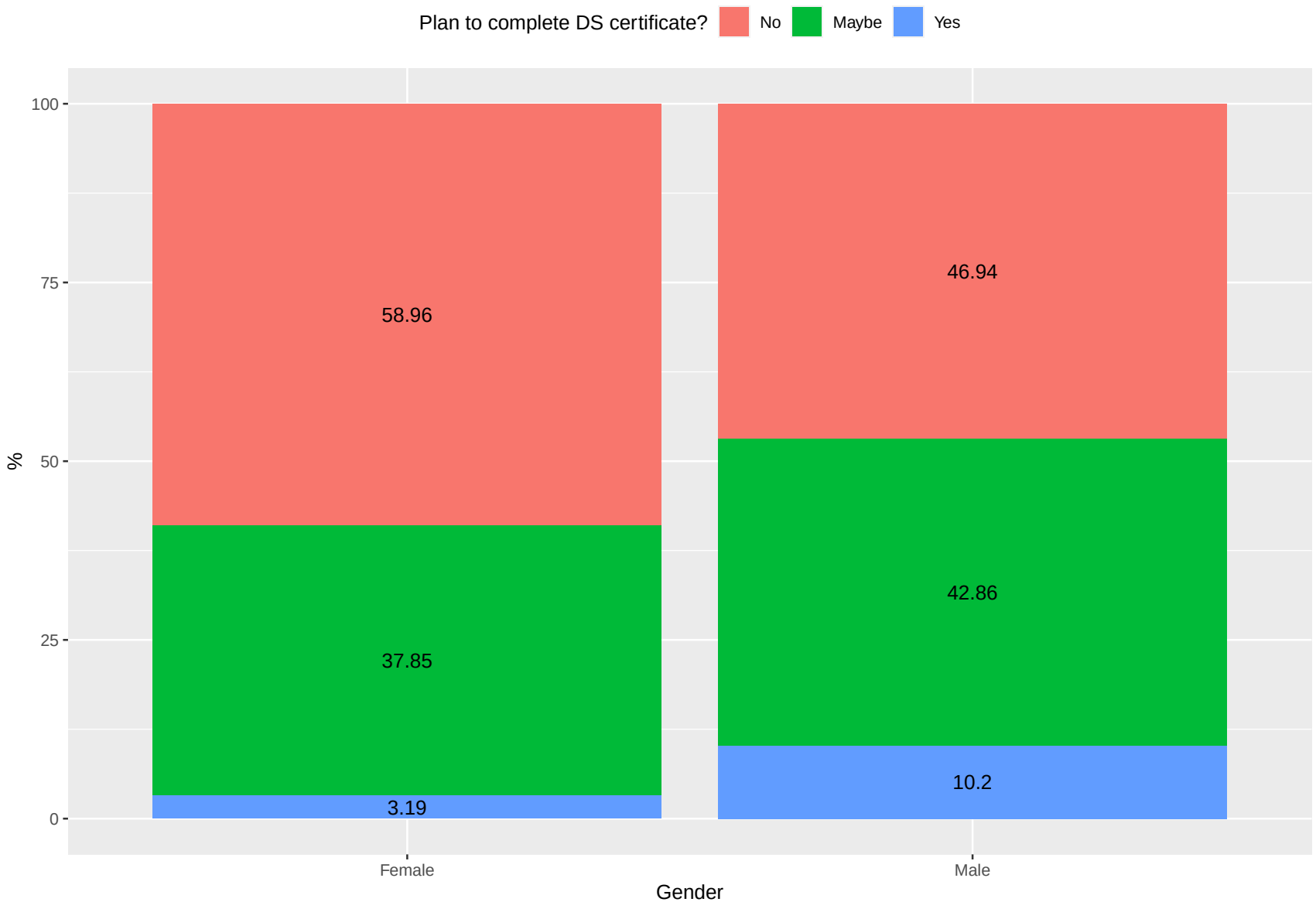
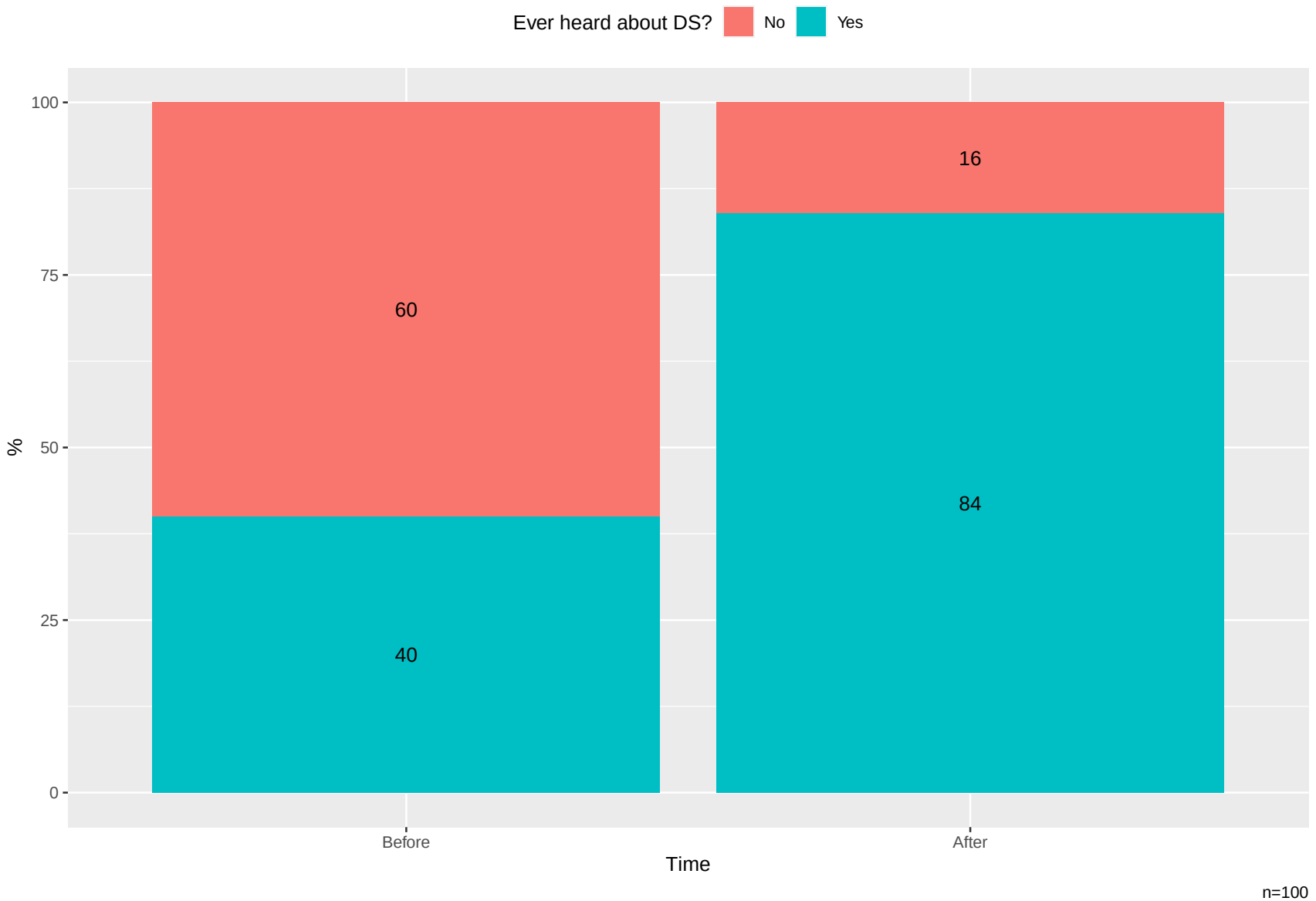


The Potential of Intro Stats to Promote Data Science

- **Intervention**:
  - Introductory lecture about the DS field and its opportunities
  - 45 minute informational presentation given during normal class session near middle of semester
  - Presentation is either given by the section instructor or course coordinator
  - Students completed the online DS awareness & aspirations survey before and after the lecture
  - 3 sections in Spring 2021 and 1 section in Summer 2021

The Potential of Intro Stats to Promote Data Science



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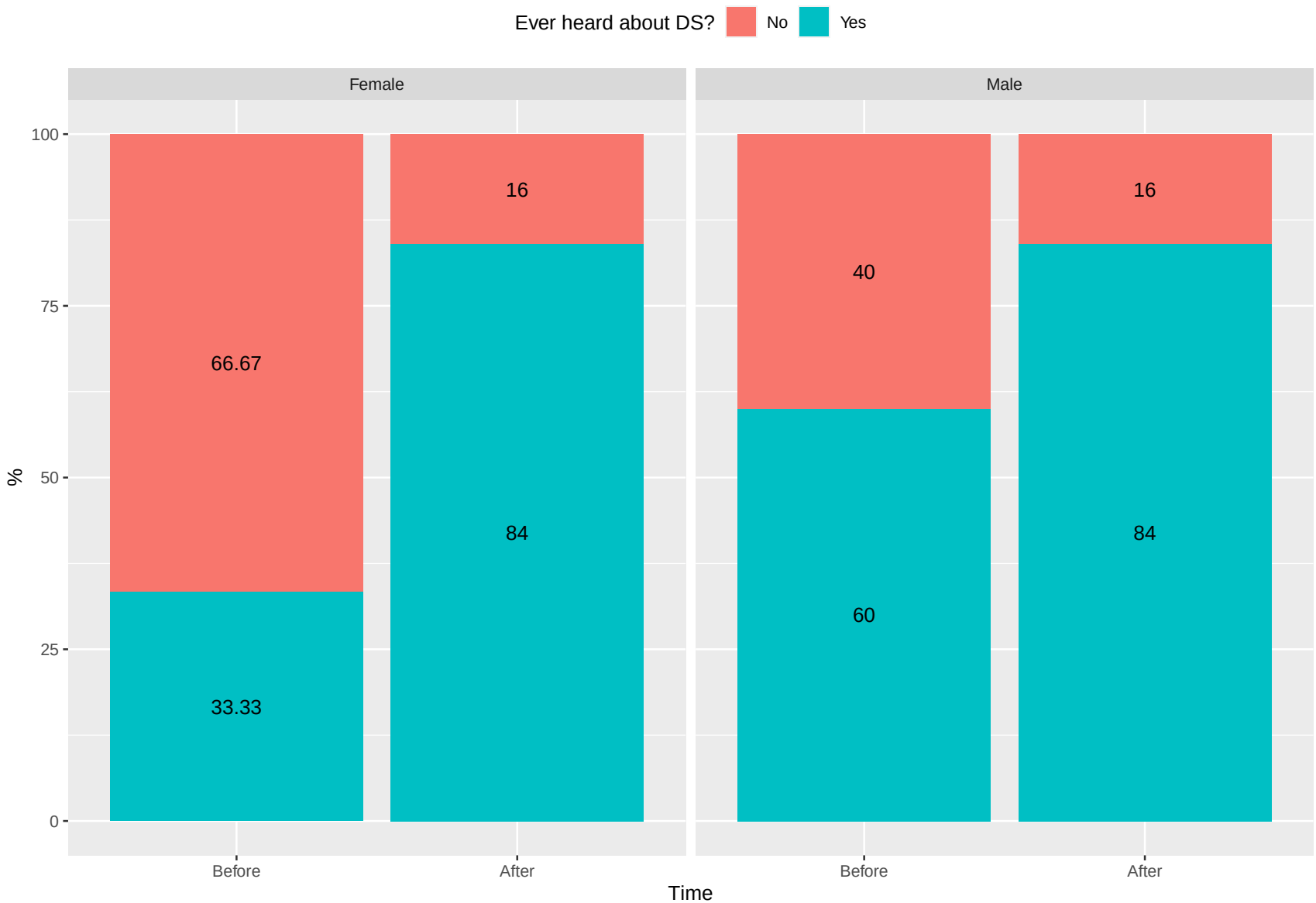

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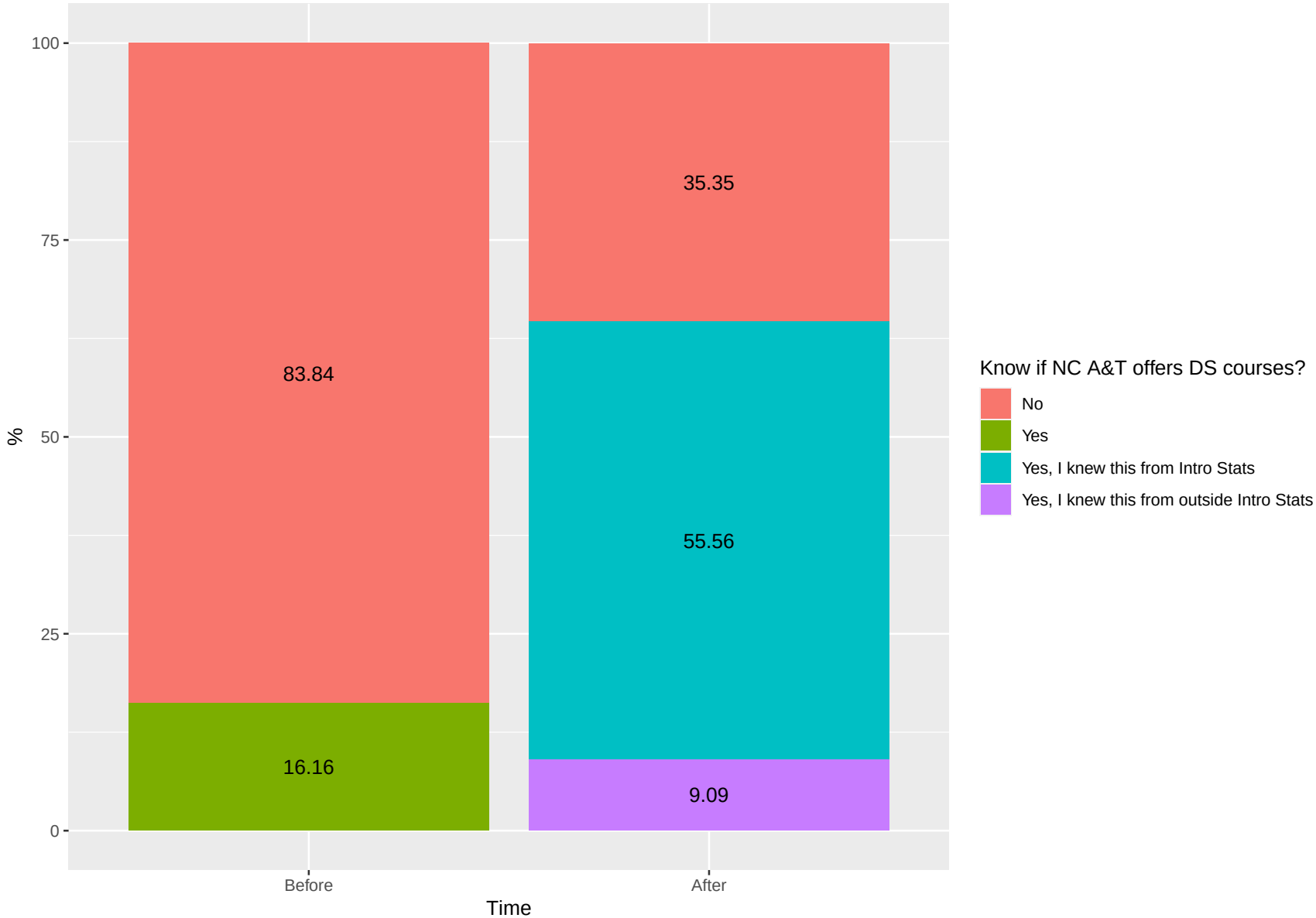

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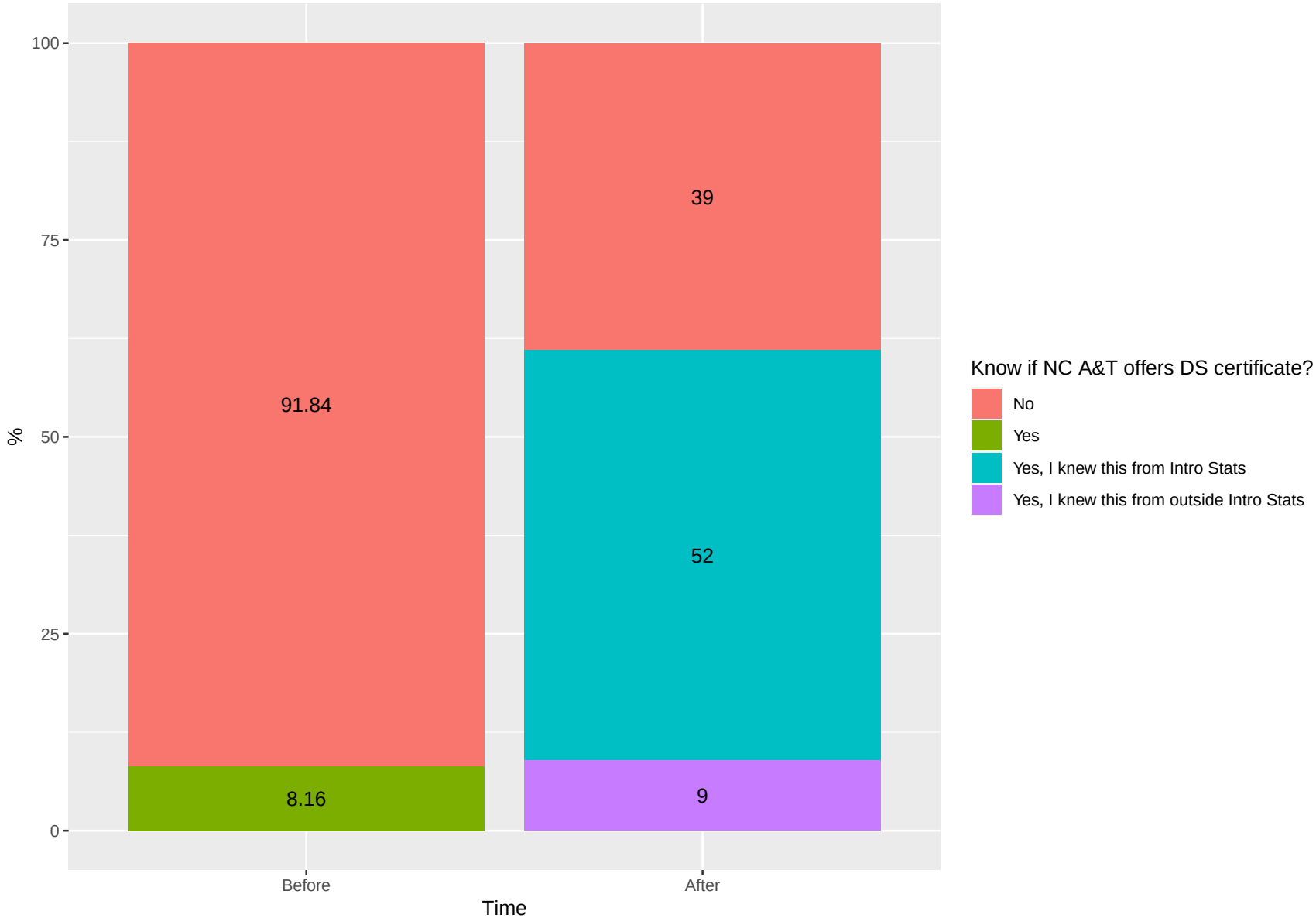

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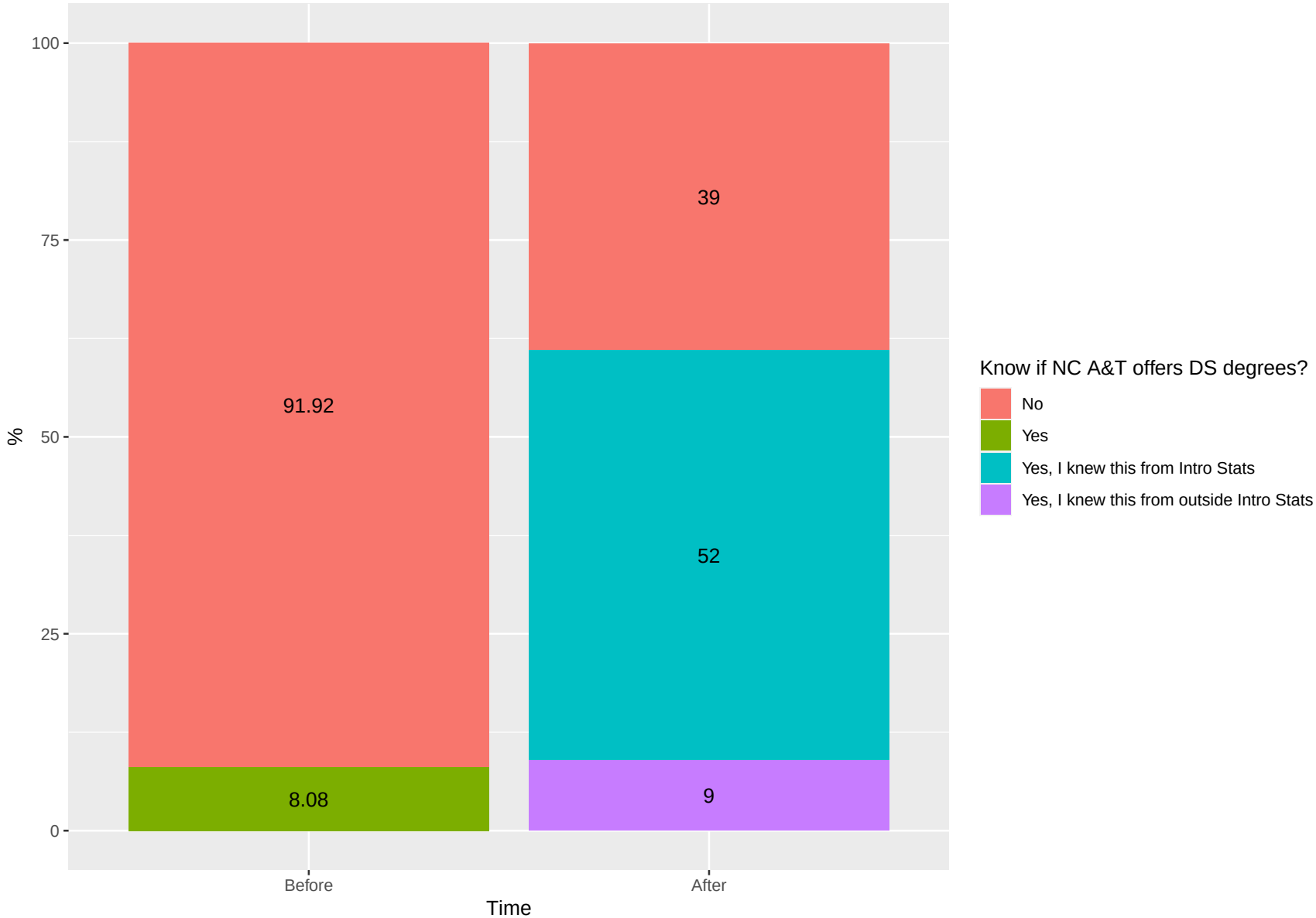

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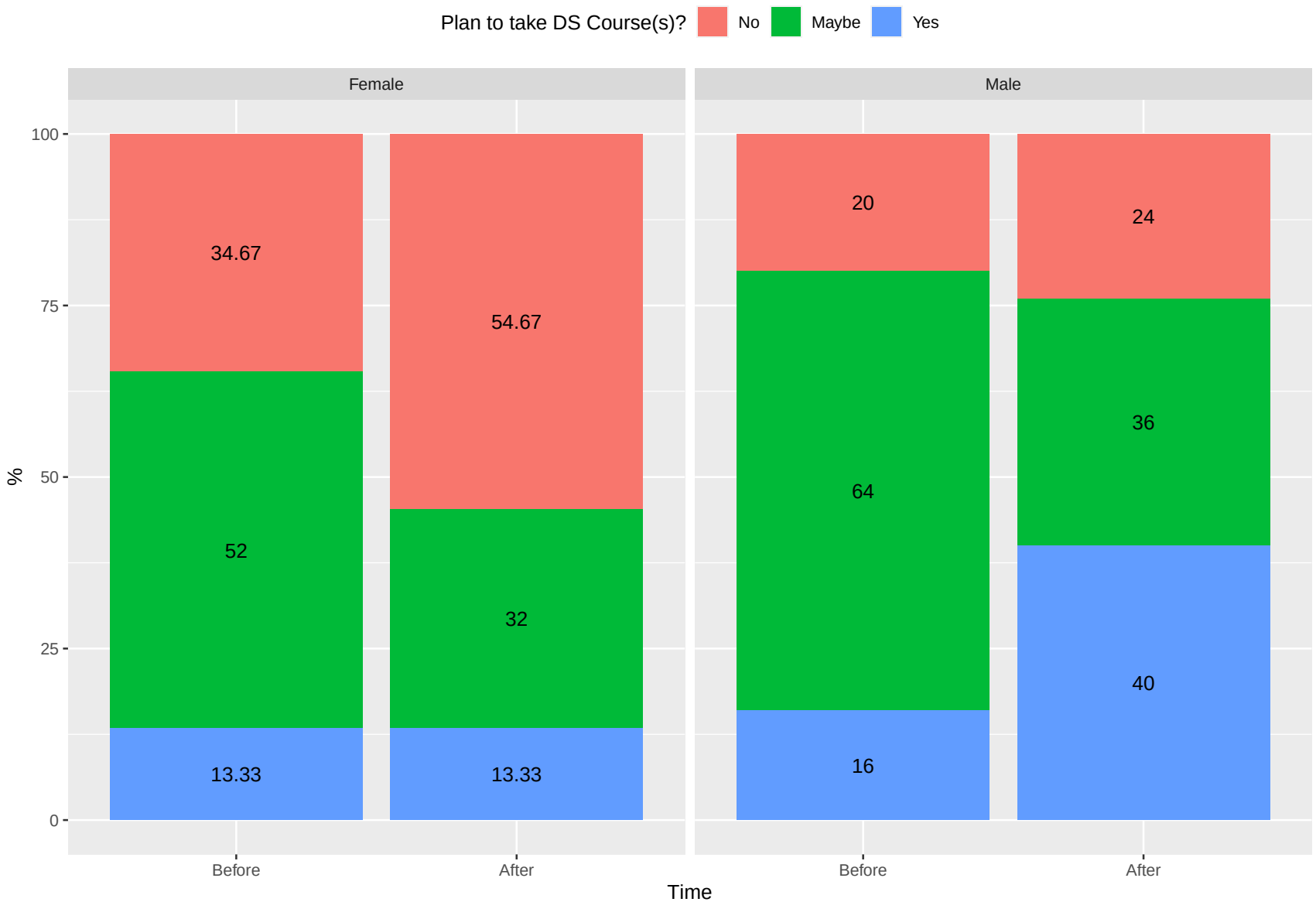

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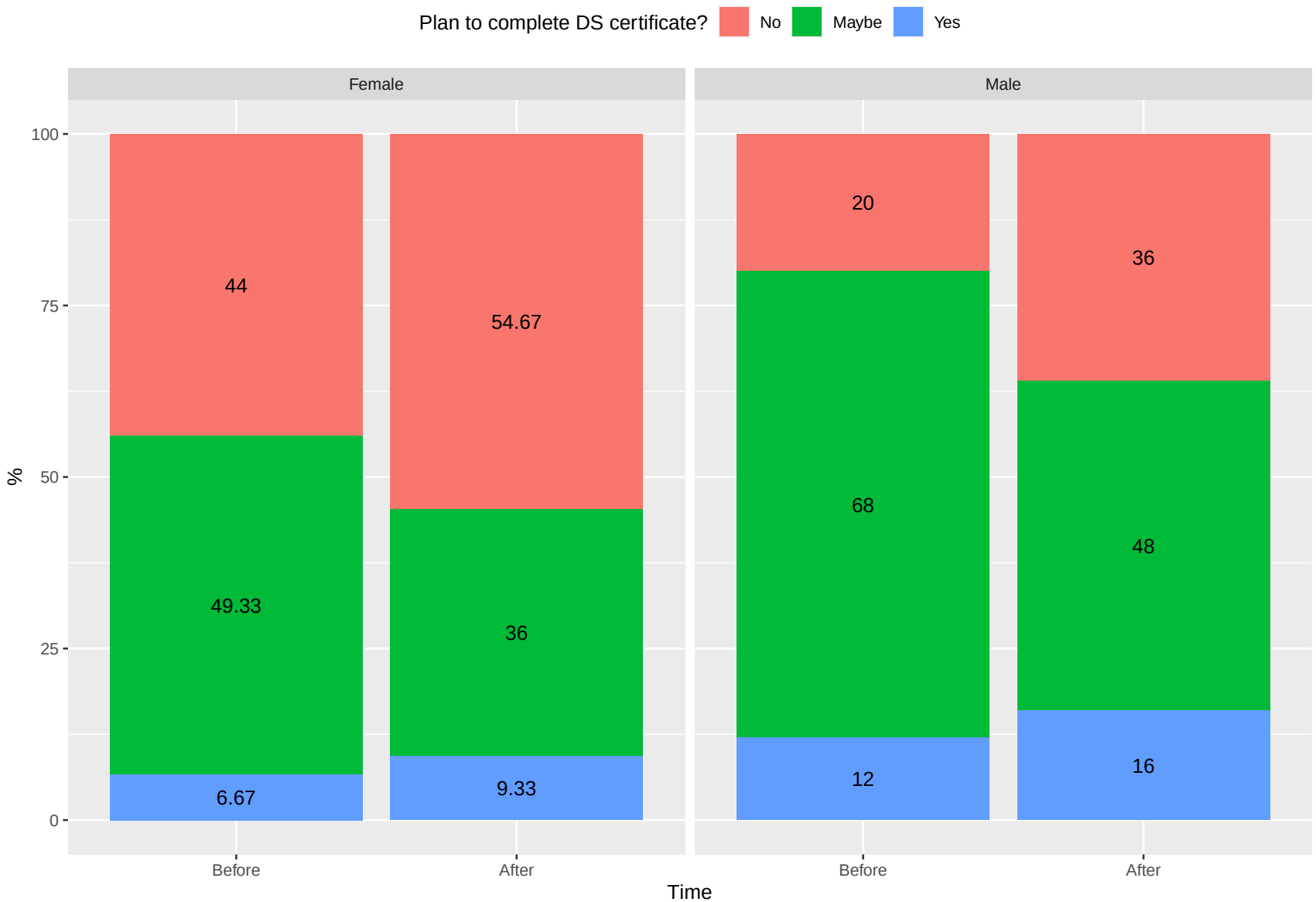

Redesigning Intro Stats to Promote DS at NCA&T

Goal: revolutionize Intro Stats at NC A&T to enhance the statistical and quantitative skills of and promote data science literacy among underrepresented minority (URM) students.

- The Intro Stats course should
  - introduce students to the entire data analysis cycle rather than pieces of it (**Cobb, 2015**)
  - leverage the use of technology for exploring concepts with simulations (**GAISE #2**)
  - help students learn statistics actively while analyzing real data using technology (**GAISE #3, 4 & 5**)
  - expose students to multivariable thinking (**GAISE #1**)
  - train students to think structurally with data, become data-savvy, and
  - expose students, early and frequently, to the elements of the DS workflow and the data scientist's toolbox

Redesigning Intro Stats to Promote DS at NCA&T

- Revised course content:

Content of the redesigned Intro Stats course.	
1. Introduction to elements of data analysis • Data analysis workflow (research question, data acquisition, cleaning, wrangling, visualization, modeling, and interpretation) **2. Data collection/acquisition** • Target population vs sample • Sampling variation and generalization • Sampling and resampling • Data from designed experiments **3. Univariate descriptive statistics** • Graphics (bar charts, dot plots, histograms, boxplots, and density plots) • Numerical summaries (five-number summary, mean, standard deviation, and standardized scores) and detect outliers **4. Bivariate relations** • Scatterplots, correlation, and causation • Contingency tables for categorical variables • Faceted plots for displaying relations across different levels of categorical variables	• Simple linear regression **5. Probability, chance models and sampling distributions** • Basic probability rules, conditional probability, and independence • Binomial and normal probability models • Sampling distribution of sample mean/proportion with simulations **6. Inference for one population mean/proportion** • Construction and interpretation of confidence intervals • Classical t-tests and resampling tests for one mean/proportion • How large is the evidence (effect size)? • Statistical versus practical significance **7. Inference for two population means/proportions** • Construction and interpretation of confidence intervals for difference bet. two means/proportions • Classical t-tests and permutation tests for two groups • Using plots to check assumptions **8. Multivariate relations** • Multiple linear regression & analysis of variance

Redesigning Intro Stats to Promote DS at NCA&T

- Adding **Virtual Statistical Computing Lab**:
  - 1-hour-long weekly **virtual lab** using RStudio Cloud
  - **Before lab sessions**, students will complete assigned interactive shiny tutorials involving reviewing concepts from lecture, examples and runing R codes
  - **During lab sessions**, students will be guided to write and run R codes in RStudio Cloud
  - **At the end of each lab session**, students will submit a lab report written using **R Markdown**
- Well-aligned with the principles of the data-centered pedagogy

Redesigning Intro Stats to Promote DS at NCA&T

- **Integration of DS knowledge and tools in the course:**
  - Horton et al. (2015) argue that *"by introducing students to commonplace tools for data management, visualization, and reproducible analysis in DS, and applying these to real-world scenarios, we prepare them to think statistically"*
  - The DS precursors integrated into the course will include:
    - **R & RStudio** to engage students in substantive data analyses and allow them to practice answering questions with data
    - **R Markdown** to train students to perform reproducible analysis
    - **Datasets that satisfy the 3 R's** of Kim et al. (2018) (Rich: to answer meaningful questions, Real: has context, and Realistic: needs wrangling; e.g., `gapminder` and `fivethirtyeight`)

Redesigning Intro Stats to Promote DS at NCA&T

- **Integration of DS knowledge and tools in the course:**
  - Reading assignments on DS projects from famous data scientist employers (Google, Amazon, Facebook, etc.)
  - Major-related data analysis projects (e.g., Kinesiology majors are assigned projects related to sports analytics)
  - Posts about current trends in the DS job market
  - Posts about DS educational opportunities

Redesigning Intro Stats to Promote DS at NCA&T

- NSF Grant #HRD2106945 (07/2021 – 06/2024)
  - PI: Sayed Mostafa
  - Co-PIs: Seongtae Kim, Guoqing Tang, Tamer Elbayoumi, Mingxian Chen
- Project Title: Infusing Data-Centered Pedagogy and Data-Analytical Skills into Introductory Statistics
- Project Goals:
  - **Enhance** the students' statistical knowledge and data-analytical skills gained from the Intro Stats course;
  - **Create** a pipeline for the DS programs offered at NC A&T;
  - **Build** a faculty cadre capable of and committed to teaching Intro Stats using a data-centered pedagogy to promote DS literacy among undergraduate students

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