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Bridging Information Literacy and Data Science: A Collaborative Approach to Project-Based Learning

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Abstract

This work-in-progress paper explores a collaboration between an engineering librarian and a data scientist to integrate information literacy (IL) concepts into a semester-long data science project. Using a library setting, the goal is to bridge the gap between technical skills and the ability to critically evaluate, manage, and ethically use information in data-driven research. Throughout the semester, the librarian works closely with students and the data science instructor to introduce IL skills such as data sourcing, citation management, intellectual property awareness, and critical evaluation of sources. By embedding these competencies into project-based learning, the initiative seeks to foster students' understanding of the ethical and effective use of data in both academic and industry settings. This interdisciplinary approach demonstrates how information literacy can enhance data science education by promoting critical thinking and responsible data practices. The paper will incorporate initial results from pre- and post-project surveys of the students along with the structure for scaffolding the IL skills within the data science project.

Introduction

Data science combines statistics, computer science, and domain-specific knowledge to analyze and interpret complex datasets. Using the results of these analyses, researchers in diverse fields drive innovation through better-informed decision-making. The growth of data science as a discipline reflects the increasing demand for data analytics to address global challenges and optimize processes in sectors including engineering and education. ASEE recognized this recently by establishing a Data Science and Analytics Constituent Committee in 2023 to “build and support member interest in data science and analytics as it relates to engineering research and education” [1].

As higher education institutions continue to adopt new data science curricula, many academic libraries are finding ways to support this shift [2]. This support ranges from more passive support, such as providing information through LibGuides and websites, to more active support, such as providing data science workshops [3] that include such topics as data visualization [4], [5], programming languages, and geographic information systems [6]. Some libraries, including our own, have embedded their own data science units within the library to act as central areas for data science education, workshops, mentorship, and research collaborations [7].

At our institution, our library-based data science unit sponsors semester-long workshops that allow students to work with data scientists to tackle real-world challenges while developing data

science, data visualization, and presentation skills. In Fall 2024, we recognized that while the students were developing their skills to analyze data sets, they could also be developing their skills to locate that information and organize it effectively. Where a data scientist would be the natural instructor to lead the data-analysis side of the project, an academic librarian would be most appropriate to discuss the information literacy skills. Accordingly, we developed a program where the data science projects would also include an information literacy facet to be guided by an engineering librarian.

This work-in-progress paper discusses the lessons learned from this initial collaboration, feedback from the students who participated in the project, and our plans to continue the collaboration into the Spring 2025 semester. Quantitative surveys of students in the projects exhibited positive trends with respect to their familiarity with statistical concepts and increased confidence in their data science skills. Interviews with a smaller set of the students provided qualitative evidence that the students improved their knowledge of, and experience with, informational literacy skills. These results highlight the important role of libraries in bringing these topics to students from various disciplinary backgrounds.

Background

The Open Project Program

Academic libraries are committed to providing access to data and information as they strive to support research and learning in an accessible environment to students from all disciplines. The multi-discipline approach afforded by libraries gives them a unique positioning to strengthen the data science and information literacy of the student community by creating learning environments that transcend traditional academic "silos." Recognizing this opportunity, the Unit for Data Science and Analytics at Arizona State University (ASU) Library developed the Open Project program to provide students from various academic backgrounds with opportunities to learn and apply data science tools and concepts.

The Open Project program offers a series of semester-long challenges that align with current industry and academic needs. Each Fall and Spring semester, the data science unit offers two to five project tracks that cover a range of topics and difficulty levels, accommodating students' diverse interests and skill levels. The tracks are implemented using current library assets and facilities, publicly available data, and open-access tools and software. The project tracks are promoted on the library's website, discussed in the data science unit's blog, and presented to the student community through a hybrid recruitment event with both in-person and online facets.

Each project incorporates five or six one-hour workshop-style meetings throughout the semester, where student teams collaborate as they learn and practice skills to help them successfully

resolve their project. Student teams are self-formed based on topic interest and consist of a mix of undergraduate and graduate students with a range of prior experience with data science. The projects are curated and led by a data science specialist and a digital humanities data analyst who are part of the Unit for Data Science and Analytics team. Projects are identified ahead of time as being more appropriate for beginning-level or more advanced students. Four topics were explored during the Fall 2024 semester:

- RetinoVision: Pioneering Retinopathy Detection with AI;
- ConsumerVoice: Complaint Analysis with NLP and AI;
- GlobalEchos: Analyzing Climate, Security, and Gender in UN Debates; and
- School Funding in the Spotlight: Data Science for Educational Equity.

Project meetings are scaffolded so that student volunteers can learn a wide range of skills and concepts as they address problems with practical applications, from understanding basic statistics to adjusting machine learning parameters. During the semester-long program, our data scientists guide students through the projects' phases, providing training on best practices, and offering office hours to support the participants' unique learning path. To wrap up the projects, our data science unit organizes a public showcase near the end of the semester, where students can present their work and final solutions to a public audience, further enhancing their professional portfolios.

Information Literacy Instruction

During discussions in August 2024, the authors realized that as the students were developing data science skills within the physical space of the library, the natural opportunity presented itself to simultaneously develop their information literacy skills under the umbrella of the Open Project. A quick review of the literature at the time, as well as a more structured search later, uncovered multiple examples of data science instruction being incorporated in academic libraries [2], [3], [4], [5], [6] as well as instances of information literacy instruction being presented in project-based courses [8], [9]. However, no specific examples of information literacy being combined with a data science project were discovered in the literature.

Enthused by this opportunity, in Fall 2024 we introduced an information literacy element into the Open Project team working on educational equity issues with respect to school funding; there was no particular reason for choosing this subject other than the collaboration of the authors, one of whom was advising this Open Project team. While past student anecdotes recounted how their data science skills grew through their participation in the projects, skills such as identifying, evaluating, and organizing data and informational sources were not explicitly included in the workshops. An engineering librarian and a data science specialist then worked together to weave information literacy concepts and skills into the workshops as the semester progressed.

The resulting workshops helped students learn information literacy skills that tied directly to their project work. While the majority of each team meeting was devoted to data science topics, five to ten minutes were set aside for an information literacy topic related to the specific focus of the meeting. Topics and the related data science concepts included:

- *Finding datasets* using library and open web resources, which occurred as the students were introduced to the dataset they used for the semester;

- *Evaluating sources*, which occurred as the students discussed how to deal with "messy" datasets and address such issues as missing or errant data;

- *Searching academic databases*, which occurred as the students were tasked with finding scholarly sources using their dataset or discussing methods of data analysis; and

- *Managing citations and sources*, which occurred as the students created a shared Zotero library to collaborate and share relevant scholarly resources.

The information literacy instruction during team meetings was scaffolded to build on previous concepts and targeted to address immediate needs the students had during their project. In addition, both the data scientist and librarian remained available to the students to consult–in-person, virtually, or through e-mail–as questions arose during the semester.

Methods

To measure and understand the students' experiences, as well as the efficacy of our Open Projects in helping them increase their data science and information literacy, we prepared quantitative and qualitative instruments (IRB study # 00020445) and invited our students to participate. Our data collection included pre- and post-surveys as quantitative measures and a series of student interviews throughout the semester as qualitative measures. Students could participate voluntarily in this research initiative or continue their projects without the research element.

Due to the small size of our project teams, we worked closely with the IRB office to ensure that all data provided by the students stayed anonymous while allowing us to still track their data science and information literacy progression throughout the semester. This included a prompt for generating a reproducible ID that students could use whenever they volunteered their data. The IRB office approved our data collection tools, recruitment materials, consent forms, and all relevant data collection and data management procedures before the beginning of our research initiative. Participants were not compensated for their time spent in the surveys or interviews.

Data Science Literacy Survey

As we set out to understand how participating in a library-led data science project could positively influence the students' data science literacy, our team put together a survey that was administered before the students' first project meeting and after their final project presentation. During the creation of the survey, our team found that the Survey of Attitudes toward Data Science (SADS) instrument, developed by the Data Science Infused into Undergraduate STEM Education (DIFUSE) project to measure undergraduate students' attitudes towards data science [10], [11], aligned with our operationalization of data science literacy. Using SADS as a starting point, we modified the survey to align with the experience of a discipline-diverse group of students.

The final survey (Appendix A) included demographic items followed by questions on four aspects, or "factors," that were of interest as we sought to understand and measure changes in the students' data science literacy. These factors were "Concept Familiarity," "Interest in Learning Data Science," "Attitude toward Data Science," and "Data Science Confidence." For our purposes, we defined these factors and measured them as follows:

- *Concept Familiarity:* As a team, we identified a set of fourteen foundational concepts relevant to data science work and presented them as items to the participants. Students were asked the question "What is your level of experience with the following data science and statistical methods?" followed by general topics such as "data visualization," "hypothesis testing," and "machine learning." Students then measured their experience level on a five-point Likert scale from "no experience" to "expert."

- *Interest in Learning Data Science:* The items in this factor measured the students' desire to learn through the project, comprising ten items. Students selected their level of agreement with each statement on a 5-point Likert scale from "strongly disagree" to "strongly agree." This factor contained items such as "I want to learn how to gain knowledge and insights from large datasets" and "I am interested in learning data science skills to solve real-world problems in industry."

- *Attitude Toward Data Science:* This factor had six statements on which students marked their level of agreement using the same 5-point Likert scale as Interest in Learning Data Science. Included were statements like "The ability to use data to answer complex questions is an essential skill in the world today."

- *Data Science Confidence:* The final set of items presented to the students asked them to rate their ability to complete data science-related tasks such as "Use descriptive statistics and charts to explore a dataset" and "Use data science concepts to help raise public

awareness of social issues." Students rated their confidence on seventeen tasks using a 5-point Likert scale from "Not confident at all" to "Completely confident."

Qualitative Interview Series

We invited our participants to a series of Zoom interviews in which we asked them about their experience with the projects. While the factors in our survey were specific to data science literacy, we used a semi-structured interview approach to give students the liberty to talk about their experience and provide feedback to the team on the quality of teaching and what could improve their learning. Each student was invited to participate up to three times throughout the semester, with each interview lasting under forty-five minutes. Interviews were recorded through Zoom, and the transcriptions generated by Zoom will be used for future thematic analysis, which is expected to yield insights that may help improve students' learning experiences. While a full qualitative analysis of the interviews is beyond the scope of this present work, we share some of the insights obtained from them. The full interview protocol is available in Appendix B.

Preliminary Results & Discussion

At this stage in our research project, our results are preliminary yet promising. The voluntary nature of the Open Project program and our research element meant that students could drop out of their project at any point in the semester. We have found from previous and present student project cohorts that as their academic load increases during the semester, some students might have to prioritize their courses and cease participating in the projects. Similarly, students might drop out of the project due to frustration with their learning or progress during the project. Accordingly, our results may be skewed by the self-selection of students who are more driven to complete the project or more comfortable with their progress. Overall, we had nine students reach the end of the projects. The attrition during the course of the project and the voluntary nature of the research initiative limited the continuity of our data collection efforts, so here we discuss the results of our pre (N=18) and post (N=6) surveys separately.

Survey Results

Our pre-survey results showed that most incoming students had a highly positive attitude toward learning data science skills and methods, with an average *Attitude toward Data Science* of 4.88 (SD=0.35) out of 5. This was also reflected in their *Interest in Learning Data Science*, with an average score of 4.87 (SD=0.44) out of 5. Thus, at the project's onset, most students showed a great desire to learn, which could be expected from students volunteering their time to increase their professional skills.

As we moved on to *Concept Familiarity*, we found that this factor was a telling proxy for the students' skill levels. We considered the first seven of the items in this factor as foundational statistics skills (e.g., hypothesis testing or linear regression, see Appendix A). In contrast, the next seven items were considered advanced data science skills (e.g., text analysis and neural networks, see Appendix A). Here we found that most of the undergraduate participants (n=8), and graduate students who did not major in a data science-related field (n=4, non-DS) had a low average familiarity with foundational statistical concepts (m=1.69, SD=0.74) and advanced concepts (m=1.25, SD=0.46). This group also reported moderate *Data Science Confidence*, with an average overall score of 2.64 (SD=1.32). In contrast, graduate students from fields directly related to data science (DS) reported higher familiarity with statistical concepts (m=3.19, SD=0.92) and advanced concepts (m=2.71, SD=0.86), and had higher confidence in their skills related to data science (m=3.45, SD=1.06). The comparison can be found on Fig. 1.

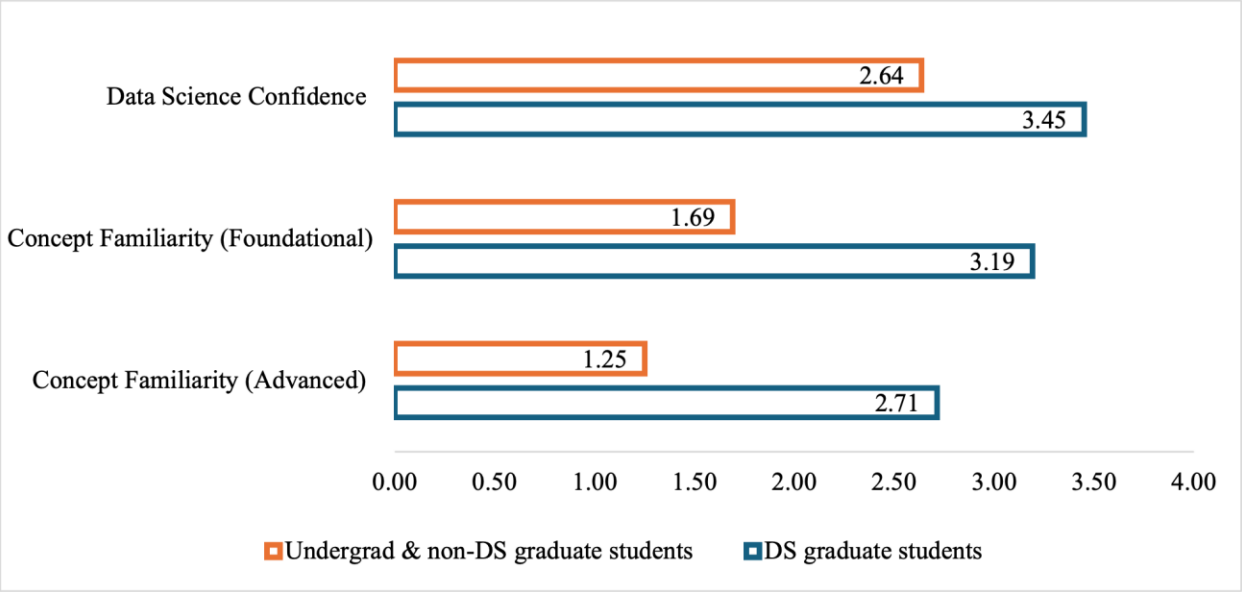

Fig 1. Concept Familiarity, and Data Science Confidence pre-survey results comparison.

At the project's close, we found that students who finished reported overall higher familiarity with statistical concepts (m=3.40, SD=0.83), while their familiarity with advanced concepts remained moderate (m=2.50, SD=0.94). Additionally, they exhibited increased confidence in their data science skills, with an overall average score of 3.71 (SD=1.04), as shown in Fig. 2.

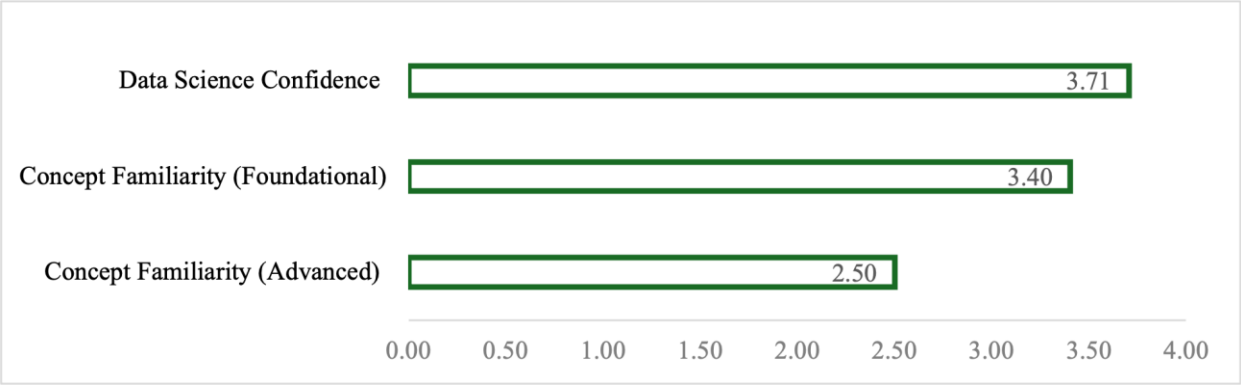

Fig 2. Concept Familiarity, and Data Science Confidence post-survey results

Qualitative Interview Insights

The student insights obtained through the interviews allowed us to understand more fully how participating in the projects benefited the students' information and data science literacy. In general, students welcomed the opportunity to practice their statistical, data science, and coding skills in a library environment (as opposed to the classroom) with a lower perceived risk.

When asked about their experience learning about information literacy, most students confessed to not knowing how to search research databases available through the institution's library access before the workshops. Graduate students especially appreciated learning about reference managers and found them to be a takeaway directly applicable to their daily work. Further, students gained a critical view of how data is collected and used, helping them further evaluate how the data used in their project had been collected, and the implications behind it.

Another takeaway from the interviews was the importance of having a variety of topics that extend beyond the typical data science project direction. Of our projects, two tracts dealt with social science-related issues; this served to attract students who would have otherwise considered the projects beyond their current skillset, and helped them persist through the more uncertain parts of their projects.

Future Work & Concluding Thoughts

We are buoyed by the results from the first iteration of this project. Students not only developed practical experience in data science but also improved their information literacy and research skills. Importantly, the students reported feeling more confident in their abilities to navigate research databases, manage citations, and assess the quality of data. They also developed transferable skills such as selecting data analysis techniques, using appropriate data analysis tools and software, storytelling through data and data visualization, and presenting findings and conclusions in a public forum.

Building on this success, we intend to expand the library consultations to both Open Projects during the Spring 2025 semester (there are only two during the Spring semester). Using the feedback from the first cohort of students, we hope to create useful learning objects and handouts for the teams that will enhance their abilities to learn the tools presented and supplement the direct instruction provided during the biweekly meetings. This will allow us to refine the program further and gather additional insights into the impacts of collaborations between data scientists and librarians in the realm of project-based learning. We intend to publish more detailed results, conclusions, and recommendations after more program iterations in 2025.

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Appendix A. Adapted SADS Instrument

ARID Please create an Anonymous Reproducible ID by following these steps: 1. Take the first three letters of your mother's maiden name. 2. Add the double-digit number of the month you were born (e.g., January = 01, May = 05). 3. Add the last 3 digits of your phone number. For example, if your mother's maiden name is Rodriguez, you were born in June, and your phone number is 123-456-7890, then your Anonymous Reproducible ID would be "Rod06890". Please enter only your Anonymous Reproducible ID in the designated box below.

Projects: Which project are you participating in? (mark all that apply)

- RetinoVision: Pioneering Retinopathy Detection with AI (1)
- ConsumerVoice: Complaint Analysis with NLP and AI (2)
- GlobalEchos: Analyzing Climate, Security, and Gender in UN Debates (3)
- School Funding in the Spotlight: Data Science for Educational Equity (4)

Affiliation: What is your current affiliation to [Blinded for review]?

- Undergraduate Student (1)
- Graduate Student (2)
- Staff (3)
- Faculty (tenure-track) (4)
- Adjunct Faculty (5)

School: What school or college do you belong to?

Major: What is your major? (Please avoid using abbreviations)

Age: What is your age?
- 18-24 (1)
- 25-34 (2)
- 35-44 (3)
- 45-54 (4)
- 55-64 (5)
- 65 or older (6)

Gender: How do you describe yourself?
- Male (1)
- Female (2)
- Non-binary/third gender (3)
- Prefer to self-describe (4)
- Prefer not to say (5)

Race/ethnicity: What is your race/ethnicity?

- Black/African American (1)
- Hispanic/Latino (2)
- Asian (3)
- Native American/Indigenous (4)
- Middle Eastern (5)
- Native Hawaiian or Pacific Islander (6)
- Alaskan Native (7)
- White/Caucasian (8)
- Other (9)

Previous Education: What is your highest level of education completed?

- High school diploma/GED (1)
- Some college (2)
- College degree (Bachelor's, etc.) (3)
- Advanced degree (Master's or Doctoral Degree (4)

Concept familiarity

Prompt: What is your level of experience with the following data science and statistical methods?

Scale: No experience (1), Beginner (2), Intermediate (3), Advanced (4), Expert (5)

Concepts:

- Descriptive statistics
- Hypothesis testing
- Analysis of variance
- Linear regression
- Multiple regression
- Generalized regression
- Data Visualization
- Machine Learning (Supervised)
- Machine Learning (Unsupervised)
- Sentiment Analysis
- Text Analysis
- Deep Learning
- Neural Networks
- Convolutional Neural Networks (CNNs)

Interest in Learning Data Science

Prompt: Please read each statement and select your level of agreement

Scale: Strongly Disagree (1), Somewhat disagree (2), Neither Agree nor disagree (3), Somewhat agree (4), Strongly Agree (5)

Statements:

- I want to learn how to communicate statistical findings confidently
- I want to learn how to use data science skills to solve problems in my field
- I am excited to learn about data science tools that I can combine with my major-specific knowledge to solve problems
- I am excited to learn about combining data science tools with my major-specific knowledge to solve problems
- I want to learn how to gain knowledge and insights from large datasets
- I am interested in learning about data management skills
- I am interested in gaining statistical skills
- I am interested in learning how to analyze data
- I am interested in using data for decision-making
- I am interested in learning data science skills to solve real-world problems in industry

Attitude toward Data Science

Prompt: Please read each statement and select your level of agreement

Scale: Strongly Disagree (1), Somewhat disagree (2), Neither Agree nor disagree (3), Somewhat agree (4), Strongly Agree (5)

Statements:

- The ability to use data to answer complex questions is an essential skill in the world today
- Knowing how to apply data science concepts to my work will help me succeed in my major/career
- Knowing how to create visualizations to communicate my results is useful in my future/current profession
- Knowing how to apply data science concepts to my work will help me succeed in my major/career
- It is important to be critical about how data is obtained and used
- Learning data science concepts can help me be critical about how organizations or researchers are interpreting their results

Data Science Confidence

Prompt: Please rate how confident you are in your ability to accomplish the following tasks successfully

Scale: Not confident at all (1), Slightly Confident (2), Confident (3), Moderately Confident (4), Completely Confident (5)

Statements:

- Identify potential and appropriate sources of data
- Cleaning data for analysis
- Future engineering and data transformation
- Use descriptive statistics and charts to explore a dataset
- Identify patterns in data that suggest relationships that are worth investigating

- Identify the appropriate data analysis methods to answer a question
- Identify the appropriate software or tools to run your analysis
- Identify the correct model (e.g., regression, machine learning algorithm, etc.) for your tasks or research questions
- Run your chosen model (e.g., regression, machine learning algorithm, etc.) for your tasks or research questions
- Interpret the results of your statistical analysis
- Frame a real-world problem in data science terms
- Create data visualizations tailored to your target audience
- Tell data-related stories to audiences that are not familiar with your work
- Use data science concepts to help raise public awareness of social issues
- Understand how your codes work
- Explain how your codes work to others
- Make recommendations based on the results of your data analysis

Appendix B. Interview Protocol

Interview Short Introduction (approx. 5 minutes):

By the time we start the interviews, students will already be familiar with the UDS, and our roles; regardless, feel free to begin the interview by introducing yourself and asking how they are doing. Explain how long the meeting will go for (about 45 minutes). The goal is to create a safe space for the students so they feel free to share their experiences.

- Cover a few points from the consent form (they will have signed and sent it by email before the Zoom call):
- Students are free not to answer questions they do not feel comfortable with.
- Explain that only de-identified information will be used for research purposes; their identity will always be protected.
- The interview will be recorded using Zoom, they can turn their camera on/off at any moment.
- Explain that they are free to skip any questions or to ask to end the interview at any time.
- Remind students that they can take their time to answer the questions. We will also work on their timetable and not go overtime. The whole interview should last under 45 minutes.
- Ask if they have any questions or concerns about the interview or the research in general.

After the introduction, ask if they are ok with being recorded, and hit the record button. Some of these questions can be asked in the first or last interview, as needed.

Background questions

1. How did you hear about the UDS projects?
    a. What caught your attention?
    b. Which project did you choose to participate in? Tell me more about what interested you to participate in this project. What led you to choose this topic? What is your connection to the topic?
2. Tell me a bit about your background, what is your major?
    a. Before participating in the project, how familiar were you with data science and analytics (this may include stat courses or such)

Data Literacy

3. What aspects of the project have you enjoyed the most so far?
4. What are some things that you have learned so far?
    a. Do you think that you might use some of this knowledge in your work outside the UDS?
    b. How do you think this will influence your future career?
5. What are some things you already knew (about the concepts or the topic itself)?
6. How did you feel about your coding skills when you started vs now?

    a. What coding languages/programs are/were you familiar with?
7. How did you feel about your data visualization skills when you started vs now?
8. Thinking back to what you have learned, how has this influenced how you think about data?
9. What has been the biggest challenge you have faced while working on the project?
    a. How would you say the UDS staff has helped you overcome these challenges?
    b. What library tools or resources have been useful to you in overcoming these challenges?
    c. What are some additional tools or resources you think could help you?
10. What has been the biggest help when working on this project?
11. How confident are you in your abilities to take the project to its final stage? Please explain.

UDS assessment questions

12. How do you feel about the way that the topics and methods are being presented?
    a. Does it match your learning style?
    b. Anything we can do to improve to assist you in learning?
13. Have you participated in any Open Labs this semester or prior semesters?
    a. How have they helped you in your project?
14. Have you come to our office hours?
    a. How have they helped you?
15. What other data science topics would you like to learn about in the future?

Closing questions

16. Is there anything you would do differently in the project to resolve the task better?
17. Looking back, what are some things you wish you knew before you started the project?
18. Looking forward to other personal projects and your current/future career, how confident do you feel in using data science tools and principles to tell a story with data?

Thank the student for their time and help, and end the recording.