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BOARD # 261: IUSE: Prioritizing Data Life Cycle Ethical Management Education for Engineering Undergraduate Researchers

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IUSE: Prioritizing Data Life Cycle Ethical Management Education for Engineering Undergraduate Researchers

Abstract

With the goal of embedding data stewardship into undergraduate research, this NSF IUSE project aims to promote effective data management, and decision-making across research projects. The project focuses on four tasks: 1) developing a data stewardship framework, 2) designing and teaching data-focused courses and workshops, 3) creating a practical guidebook as an open curriculum resource to address common data challenges and professional development needs, and (4) conducting and disseminating research. The broader implication of our research, therefore, is that, as we shape the next generation of researchers, data stewardship can serve as a foundation for integrating responsible data practices into the research culture.

Introduction

In a world where data are ubiquitous, it is increasingly important to practice ethical data management, to ensure data are findable, accessible, interoperable, and reusable (in other words data FAIR principles). However, there remains a lack of interdisciplinary endeavors that embed data life cycle ethical management education into undergraduate research academic courses in Engineering. The overall goal of this NSF IUSE project is to develop a framework and curricula that guide "data life cycle ethical management" education for undergraduate research in engineering and broadly in STEM.

In 2024, the project team developed the "Design Reasoning in Data Life Cycle Ethical Management Framework" and presented it at the ASEE annual conference [1]. The integration of three critical components of the framework (design reasoning, data reasoning, and ethical reasoning) is accomplished by centering on the conscientious negotiation of design risks and benefits. We further refined this framework into the Data Stewardship Framework (See Figure 1).

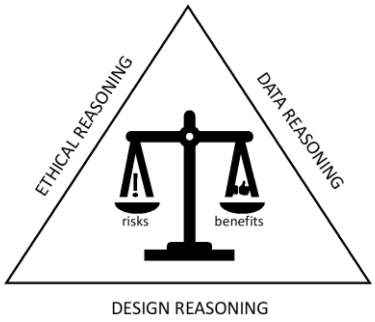

Figure 1. Data Stewardship Framework

1) Design Reasoning Quadrants Framework [2].
2) Ethical Reasoning - Reflexive Principles Framework [3].
3) Data Reasoning - Data Life-Cycle Model [4].

Data Stewardship

Data Stewardship is the care and management of data throughout the project. It involves identifying underlying disciplinary, data management, and ethical principles and articulating the

trade-offs involved in decision-making across the project lifecycle plus reflecting on future considerations and implications of those decisions.

This data stewardship framework has guided the development of a rubric, featured in the poster, which has been used to grant three awards to undergraduate researchers who effectively articulated their data stewardship practices at a Spring 2025 undergraduate research conference.

Courses for Undergraduate Researchers

Additionally, to augment the data stewardship practices of undergraduate researchers, we developed and taught stand-alone courses for undergraduate researchers as well as workshops for research mentors.

One new course "*Understanding Your Research Data*" was offered in Spring 2024 & 2025. This course applies research data life cycle ethical management principles to students' current undergraduate research experience. It entails proper research data planning, collection, description, organization, management, visualization, preservation, communication, and ethical use. Students will be able to produce research data that can be Findable, Accessible, Interoperable, and Reusable (Data FAIR principles).

Fifteen undergraduate research scholars enrolled. The course was delivered in a hybrid format, combining in-person and online sessions. As part of their coursework, students presented their final research project posters at the Purdue Undergraduate Research Expo on campus.

Results from students' mid-term reflections, final reflections, and projects indicated that the course improved their ability to work with data efficiently and ethically, increased their confidence and comfort with managing data-intensive projects, and highlighted the importance of organized data for research success. Students also expressed a need for additional scaffolding, such as worksheets and concrete examples of data stewardship practices.

To assess the curricular efforts, we will use performance assessment and surveys to obtain data from undergraduate researchers on research and data management competencies ($N > 200$ for both pre- and post-) mainly from two regular undergraduate research partnership programs. Interviews will be conducted with a purposefully selected subset of survey responses ($N = 25$ for both pre- and post-). The partnership programs' students' technical reports, reflections, and data management worksheets will be collected to triangulate with our survey and interview results.

Preliminary Research Findings

To assess the current state of data management practices in undergraduate research teams, a study was conducted using the validated Data Information Literacy Toolkit. Two graduate mentors were interviewed in Fall 2024 as part of this effort. Emerging findings from these interviews indicate that undergraduate research teams face several challenges, including inconsistent documentation, limited metadata creation, and poor data organization. Data skills are often learned "on the job", and ethical considerations are addressed briefly such as during orientation or university-wide seminars. Additional challenges include managing diverse data types with distinct lifecycles, difficulties in data presentation and visualization, and varying levels of data handling experience among students.

Addressing the Need for a Practical Guide

A practical guidebook "*Stewards of Data: A Practical Guide for Undergraduate Researchers in Engineering and Applied Sciences*" is currently under development featuring the framework and the toolkit to support efficient and responsible data cycle management. The guidebook prompts faculty, graduate mentors, and undergraduate researchers to reason through ethical considerations, future consequences, and trade-offs as they plan, collect, describe, manage, visualize, curate, and share the data, outline the stages of the data lifecycle for the specified dataset, detail data management practices, and identify tools used throughout the lifecycle.

Some examples are "Data Management Plan Checklist", "Data Preservation Protocol", "File Naming and Organization Guide", "Data Quality Checking Guide", "Metadata - Quantitative and Interview Data Dictionary Creation", "Data Storage and Backup", and "Data Repository Selection". This guidebook will be disseminated as an essential open curriculum resource designed to address the common challenges and professional development needs of undergraduates and mentors engaged in research and design projects.

Conclusion

Embedding data life cycle ethical management education into daily research practices is crucial to shaping next-generation researchers. The project aims to enable undergraduate researchers to effectively and ethically plan, access, collect, assure, describe, evaluate, preserve, and share their research data. The educational materials to be developed will advance data ethical management education and equip students to consume and produce data with concrete experience in authentic research settings.

Acknowledgments

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References

[1] S. Purzer, C. Zoltowski, W. Zakharov, and J. Arigye, "Developing the Design Reasoning in Data Life-Cycle Ethical Management Framework," in 2024 ASEE Annual Conference & Exposition, June 2024.

[2] J. Quintana-Cifuentes and S. Purzer, "Semantic Fluency in Design Reasoning," International Journal of Engineering Education, vol. 38, no. 6, pp. 1891–1903, 2022.

[3] J. Beever and A. O. Brightman, "Reflexive principlism as an effective approach for developing ethical reasoning in engineering," Science and engineering ethics, vol. 22, pp. 275–291, 2016.

[4] L. Pouchard, "Revisiting the data lifecycle with big data curation," 2015.