

UTSA CS 4593: CS-CURE

Course-based Undergraduate Research Experience in CS

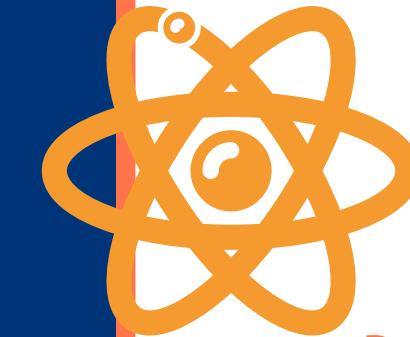
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Spring 2024



SUMMER RESEARCH EXPERIENCE FOR UNDERGRADS



Dates: May 28th - July 26th

The objective of the CONNECT Summer Undergraduate Research Experience is to provide students a multi-disciplinary environment to learn the science, the politics & policies, as well as the technology enabling advancements in nuclear security.

UTSA is recruiting high caliber undergraduate juniors and seniors from minority serving institutions across the country.



AREAS OF RESEARCH:

- Public Policy and Administration
- Fuel Cycle Materials
- Advanced Characterization and Forensics
- Computational Modeling and Data Analytics
- Detection Science

BENEFITS INCLUDE:

- SUMMER HOUSING
- \$5000 IN STIPEND AWARDS
- MENTORSHIP
- NETWORK WITH NATIONAL LAB SCIENTISTS
- RESEARCH POSTER PRESENTATION

INTERESTED? APPLICATIONS ARE DUE MARCH 21, 2024!

Scan the QR code to complete the application



Week 6: Research Design

UTSA CS-CURE

Week 6

- Objectives:
 - Formalize a research design for your project
 - Learn from expert(s) in diverse fields within CS
- Deliverables:
 - Guest Lecture Survey (in-class Thursday)

Research Design

Creating a blueprint for your work

Computer Science Research

The next step in the process: *research design*

Research Design

a comprehensive plan
outlining the framework for
conducting research
in order to answer
a specific research question

This week!

Research Methodologies

specific techniques & tools
used to collect, measure,
and analyze data
in a research project

In the coming weeks..

Computer Science Research

analogy: constructing a building

Research Design



Research Methodologies



Research Design

Fundamental components

- **Problem statement**
 - Clearly defines the problem to be addressed.
- **Research questions**
 - Specific, answerable questions derived from the problem.
- **Methodology**
 - Strategies & tools you'll use to answer the question(s).

Research Design

Rationale

- **Problem statement**
 - Identifies the research gap and sets the stage for further exploration.
- **Research questions**
 - Focuses the research by guiding data collection, analysis, & interpretation,
- **Methodology**
 - Justifies the validity of your research work.

Research Design

Example

- **Problem statement**

- Recommender systems play a crucial role in various online platforms, but limited transparency can lead to user distrust and concerns about bias. This research aims to investigate the effectiveness of Explainable AI (XAI) techniques in enhancing trust in recommender systems.

- **Research questions**

- Does increased understanding through XAI techniques lead to greater trust in the recommender system and user satisfaction?
- What specific types of XAI explanations are most effective in different user contexts and for various recommendation tasks?

- **Methodology**

- Surveys, experiments, and data analysis*

*research methodology to be expanded later

Research Design

Example types

- **Experimental**
- **Observational**
- **Case study**
- **Survey**

The type of research design you choose depends on your research questions, available resources, & the nature of your inquiry.

Each type offers distinct advantages & limitations

Experimental Design

Research designs

Definition:

Tests hypotheses by manipulating variables & observing their effects.

Rationale:

Provides strong evidence for causal relationships.

Often used in algorithm evaluation & performance comparison.

Example:

Comparing different pre-processing techniques on a benchmark dataset to evaluate their impact on the accuracy of a machine learning task.

Observational Design

Research designs

Definition:

Analyzes existing data without manipulating variables

Rationale:

Useful for exploratory research, for understanding user behavior, and for identifying patterns in datasets.

Example:

Analyzing large-scale image datasets to identify common challenges & characteristics under certain conditions.

Case Study Design

Research designs

Definition:

In-depth investigation of a single individual, group, or phenomenon.

Rationale:

Provides rich insights into specific contexts.

Valuable for understanding complex systems & user experiences.

Example:

Studying the performance of new image recognition algorithm on a specific real-world application (e.g. autonomous driving).

Survey Design

Research designs

Definition:

Collects data from a large group of participants through questionnaires.

Rationale:

Identifies user attitudes, perceptions, & preferences.

Informs design decisions and system development.

Example:

Surveying users about their experiences with image recognition systems in certain autonomous driving conditions to understand their needs & preferences.

Research Lifecycle

Taking a step back to look at the overall process

Research Lifecycle

Research isn't a single event!

1. Plan & ***design***
2. Collect & create
3. Analyze & collaborate
4. Evaluate & archive
5. Share & disseminate
6. Publish & reuse
7. Repeat!



Research Lifecycle

..from the university research office perspective



Image source: Michigan Tech

Research Design

Getting started: proposal development

- 1. Ideas** - identify a relevant & impactful problem within your area of interest
- 2. Literature Review** - conduct a thorough review of existing research to understand & identify gaps
- 3. Proposal Development** - clearly articulate your research question, methodology, expected outcomes, and potential contributions.

Research Design

The Heilmeier Catechism

DARPA operates on the principle that **generating big rewards requires taking big risks**. *But how does the Agency determine what risks are worth taking?*

George H. Heilmeier, a former DARPA director (1975-1977), crafted a set of questions known as the "Heilmeier Catechism" to help Agency officials think through and evaluate proposed research programs.

- **What are you trying to do?** Articulate your objectives using absolutely no jargon.
- How is it done today, and what are the limits of **current practice**?
- What is **new** in your approach and why do you think it will be successful?
- **Who cares?** If you are successful, what difference will it make?
- What are the **risks**?
- How much will it **cost**?
- How long will it take?
- What are the mid-term and final "**exams**" to check for success?



DEFENSE ADVANCED
RESEARCH PROJECTS AGENCY



<https://www.darpa.mil/work-with-us/heilmeier-catechism>

Research Lifecycle

Execution & analysis

- 1. Execution** - implement your chosen methodology
- 2. Data analysis** - apply appropriate statistical techniques & visualizations to extract meaningful insights from the data
- 3. Critical evaluation** - assess the limitations & potential biases of your research design & the findings.

Research Lifecycle

Dissemination & impact

- 1. Publication** - share your research findings through peer-reviewed venues
- 2. Collaboration** - seek feedback from peers & new collaborators to refine your work and expand its reach
- 3. Contribution** - aim for your research to have a lasting impact by addressing real-world problems & advancing the field

Research Lifecycle

"A day in the life of..."

Research Lifecycle

Experiences

- **What does a day in the life of a researcher look like?**
- It depends!
 - ...on your role
 - ...where you are in the project timeline

A Day in the Life of a Researcher

Undergraduate research assistant (URA)

- *Focus:* learn, gain experience, decide if research is for you
- *Activities:* participating in lab meetings, running experiments, data collection/analysis, literature review
- *Time:* 5-10* hours/week, schedule depends on PI/lab & your coursework
- Position is often “by semester” (or 8-10 weeks if “URE” or “REU”)



A Day in the Life of a Researcher

Graduate research assistant (GRA)

- Focus: conducting focused research independently (w/support of a team)
- Activities: design experiments, data collection/analysis, paper writing, near peer mentoring
- Time: 20-40* hours/week, schedule depends on PI/lab & your coursework
- Position is often for length of degree program.



A Day in the Life of a Researcher

Postdoctoral Researcher (postdoc)

- Focus: gain experience, conduct independent research, grow as a mentor
- Activities: design & lead research projects, write grants, secure funding, publish papers, mentor students
- Time: 40-50* hours/week
- Position is often a short contract (e.g. 1 year)

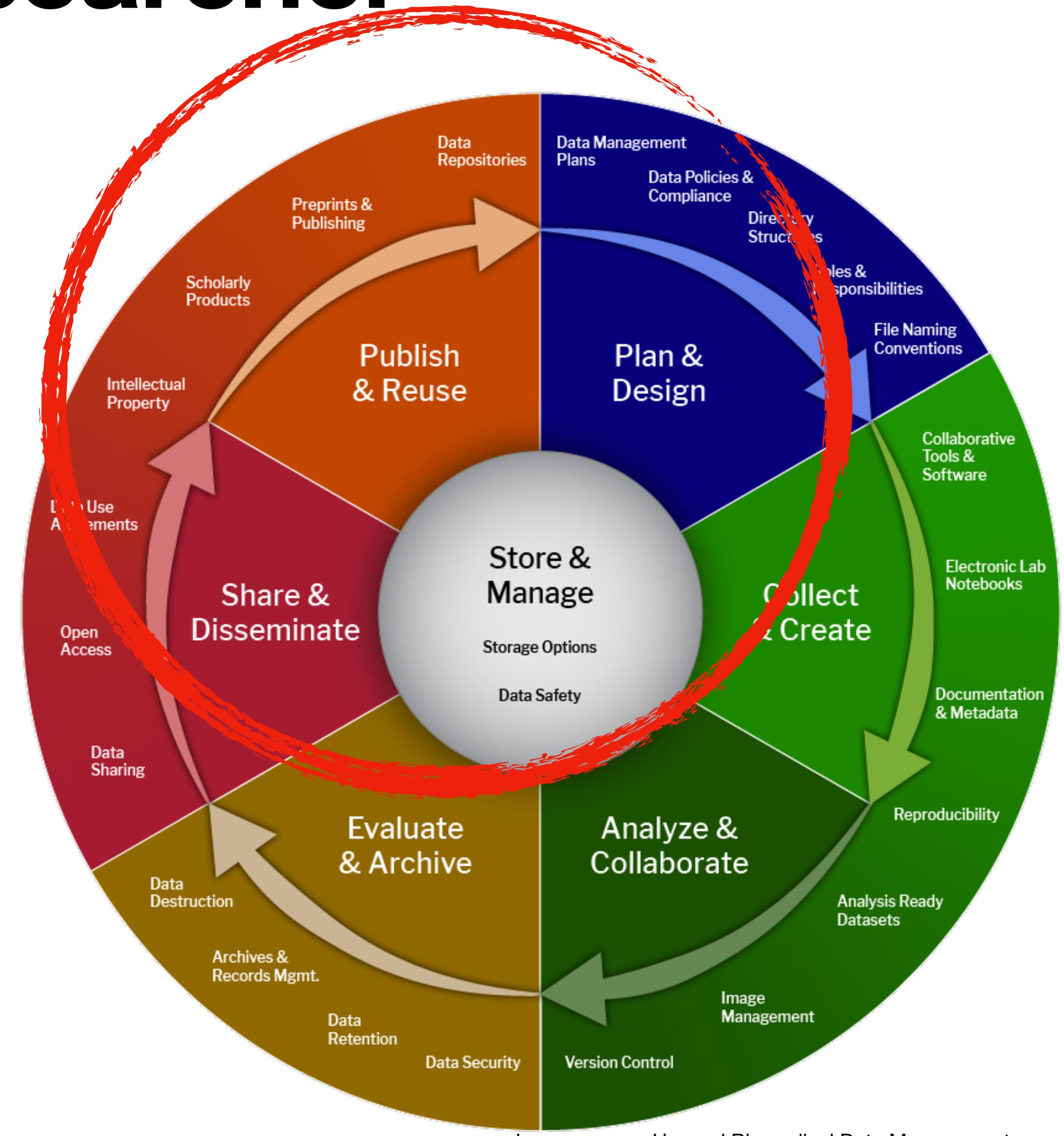


Image source: Harvard Biomedical Data Management

A Day in the Life of a Researcher

Primary Investigator (PI) - faculty member

- Focus: oversee research programs, mentoring
- Activities: design & lead research projects, write grants, secure funding, publish papers, mentor students, teaching, attending conferences, service activities
- Time: 50*+ hours/week
- Position is for 5-6 years until tenure review

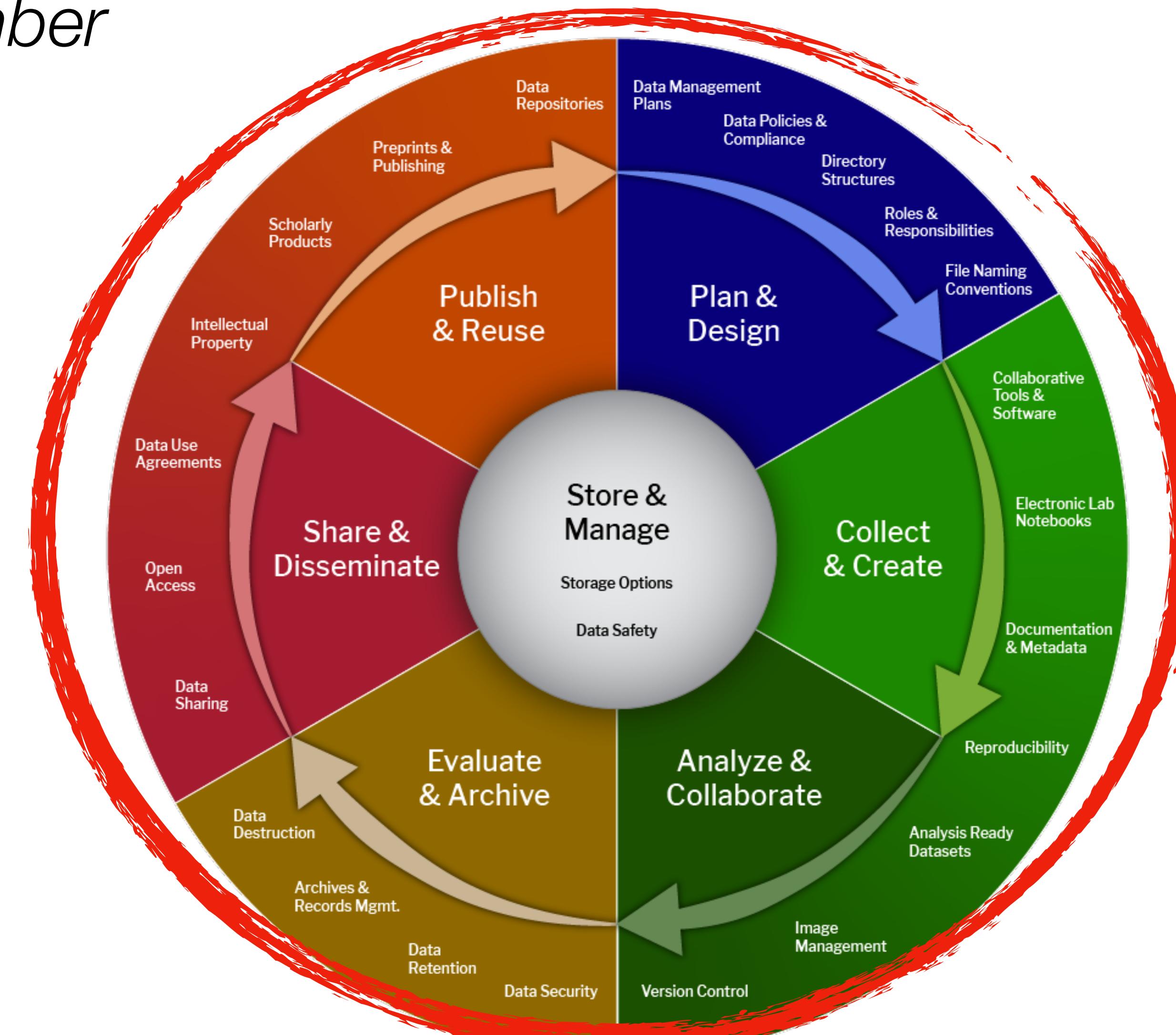


Image source: Harvard Biomedical Data Management

A Day in the Life of a Researcher

The hard parts?

- Determining if a research problem is relevant & impactful
- Allocating time effectively (*especially without deadlines or “meetings”!*)
- Every day is different (*can be tough to plan for..*)
- Research doesn’t always work out

Research Lifecycle

Q&A

- **What does a day in the life of a researcher look like?**

Research Lifecycle

Quick demo?

- **What does a day in the life of a researcher look like?**

Funding your research

<https://research.utsa.edu/fund-dev/find-funding/>

The screenshot shows the UTSA Research, Economic Development, and Knowledge Enterprise website. The header includes the UTSA logo, a search bar, and navigation links for myUTSA, Research Development, Research Admin, Manage Research, Compliance & Integrity, Collaborate & Partner, Communicate, and About Us. Below the header, a breadcrumb trail shows 'Home > Fund & Develop' and the page title 'Find Funding'. A large section titled 'Funding Process' is displayed, followed by a list of steps with '+' icons for expansion.

Funding Process

Below is a brief outline (click here to download) of the steps to be taken to find funding, and prepare and submit a proposal at UTSA. It is a general guide only; each proposal will require custom tailoring to the funding agency's guidelines. The Research Service Centers are your first point of contact for initiating the funding process at UTSA.

Identify funding opportunities and find collaborators:	+
Contact and meet with your Research Service Center:	+
Read and understand the funding agency guidelines:	+
Inform your College and Department of your intent to apply:	+
Develop and write the proposal:	+
Develop the budget:	+
Complete sponsor application and UTSA administrative forms and begin internal routing:	+
Send full proposal to your RSC for final review and submission:	+

Funding your research

[nsf.gov/funding](https://www.nsf.gov/funding)

The screenshot shows the official website of the National Science Foundation (NSF) at nsf.gov/funding. The page title is "Funding at NSF". The main content area features a sidebar with links for "Funding at NSF" (including "Finding Funding", "Preparing Your Proposal", "Submitting Your Proposal", "How We Make Funding Decisions", and "Additional Resources"), a "Share" section with social media icons, and three main columns: "Finding the right funding opportunity", "Preparing your proposal", and "Submitting your proposal". Each column includes a summary and a blue button for more information. At the bottom, there are additional sections: "How we make funding decisions", "NSF 101", and "Research approaches we encourage". A search bar and navigation menu are visible at the top.

An official website of the United States government [Here's how you know](#)

National Science Foundation

Search NSF

Find Funding & Apply Manage Your Award Focus Areas News & Events About

Funding at NSF

[Funding at NSF](#)

Finding Funding +

Preparing Your Proposal +

Submitting Your Proposal

How We Make Funding Decisions

Additional Resources +

Search for funding

Search funded projects (awards)

Share

Learn how to apply for NSF funding by visiting the links below.

f t in e

Finding the right funding opportunity

Learn about NSF's funding priorities and how to find a funding opportunity that's right for you.

[Tips for finding funding](#)

Preparing your proposal

Learn about the pieces that make up a proposal and how to prepare a proposal for NSF.

[Preparing your proposal](#)

Submitting your proposal

Learn how to submit a proposal to NSF using one of our online systems.

[How to submit a proposal](#)

How we make funding decisions

Learn about NSF's merit review process, which ensures the proposals NSF receives are reviewed in a fair, competitive, transparent and in-depth manner.

[How we make funding decisions](#)

NSF 101

NSF 101 answers common questions asked by those interested in applying for NSF funding.

[NSF 101](#)

Research approaches we encourage

Learn about interdisciplinary research, convergence research and transdisciplinary research.

[Research approaches](#)

Wrap-Up

Tuesday

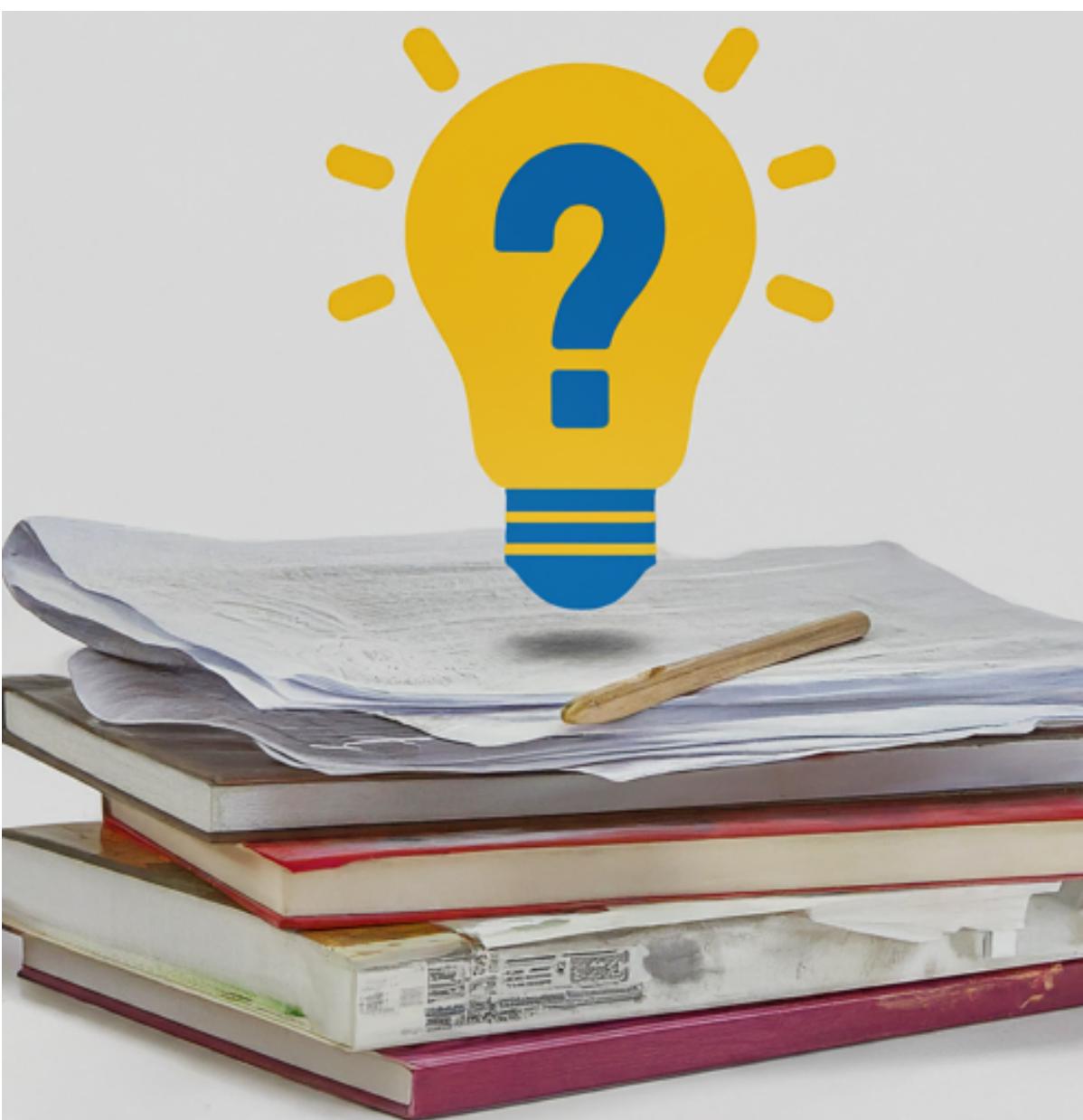
- Formalize a research design for your project
- To Do:
 - Guest Lecture Survey (in-class Thursday)

See you Thursday!

PS: something fun...

I asked an LLM to help me structure this lecture.

It gave me these :)



Guest Research Lecture #2: **Dr. Maryam Tabar**

AI For Social Good

<https://sciences.utsa.edu/faculty/profiles/tabar-maryam.html>

Guest Research Lectures

Questions for experts in the field - ask them anything!

- **About their research..**

- What challenges did you face during this research, and how did you overcome them?
- What are the real-world applications of your research?
- What are the existing approaches to your research work?

- **About their research field..**

- What emerging trends do you see? What promising new areas?
- What advice would you give to an undergraduate student interested in this research field?
- What resources or communities can you recommend?

- **About careers & skills..**

- What skills do you find important in your field?
- What was your career path?
- How do you balance your research with other academic & personal commitments?