Educating a New Breed of Data Scientists for Scientific Data Management

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Microsoft eScience Workshop, Chicago, October 9, 2012

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Talk points

- Data science (DS) and data scientists in the context of scientific data
- An iSchool version of the DS curriculum
- Findings and lessons from implementing the DS curriculum
- A new breed of data scientists: the iSchool approach

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What is data science?

"An emerging area of work concerned with the collection, presentation, analysis, visualization, management, and preservation of large collections of information."

Stanton, J. (2012). Introduction to Data Science. http://ischool.syr.edu/media/documents/2012/3/DataScienceBook1_1.pdf

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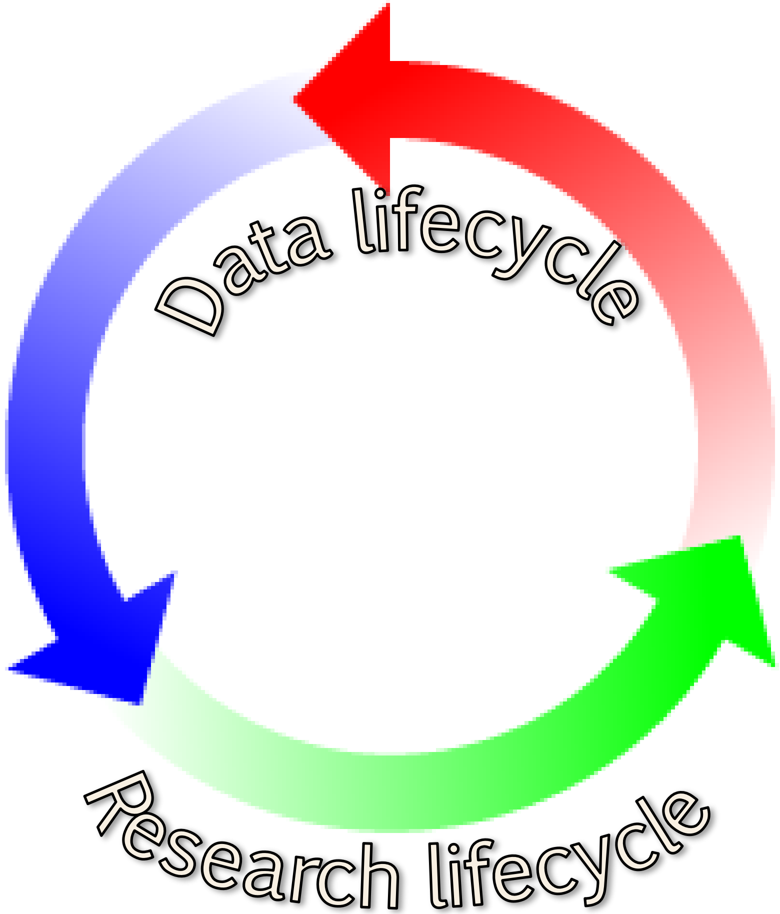
Data science and scientific research

Plan, design, consult for, implement, and evaluate data management projects and services



Ingest, store, organize, merge, filter, and transform data and create analysis-ready data

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What data scientists are expected to do: the job market

Scientific Data Management Specialist

- Design, develop, implement, and manage high-throughput automatic data processing infrastructure for large databases in a mature system
- Develop and improve the infrastructure supporting this system
- Interface with multiple data providers to design, build, and maintain their customized databases
- Clarify requirements, feature requests and bug reports for software developers and assist in testing code.

http://www.bioinformatics.org/forums/forum.php?forum_id=9670

Laboratory Data Management Specialist

- Administer operational database
- Assure the quality of data database content
- Interact closely with researchers, lab managers, and platform coordinators
- Track deliverables against budget and prepare data reports
- Collaborate closely with IT and bioinformatics colleagues
- Assist IT in gathering workflow requirements
- Test changes and updates in IT systems
- Create and maintain app documentation

Data Modeling/ Management Specialist

- Working closely with the high performance computing and the IT manager
- Develop a data model for complex multi-scale rocks
- Design and organize a database and complex queries
- Integrate and mange multi-scale rocks subjected to large-scale scientific computing applications

http://www.ingrainrocks.com/data-management-specialist/

> “We’re increasingly finding data in the wild, and data scientists are involved with gathering data, massaging it into a tractable form, making it tell its story, and presenting that story to others.”

Loukides, M. (2011). What is data science? Sebastopol, CA: O’Reilly.

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What data scientists are expected to do:
the difference from tradition

- Data scientists are more likely to be involved across the data lifecycle:
  - Acquiring new data sets: 33%
  - Parsing data sets: 29%
  - Filtering and organizing data: 40%
  - Mining data for patterns: 30%
  - Advanced algorithms to solve analytical problems: 29%
  - Representing data visually: 38%
  - Telling a story with data: 34%
  - Interacting with data dynamically: 37%
  - Making business decisions based on data: 40%

http://mashable.com/2012/01/13/career-of-the-future-data-scientist-infographic/

How should educational programs address the challenge?

A case of the CAS in Data Science program at Syracuse iSchool

Story 1: cognitive-demanding workflows and data management

- *Domain:* Thermochronology and tectonics
- *What's involved*: rock samples from drilling and field observation, sliced and grained rock samples
- *Data types*: Excel data files (lots of them), spectrum and microscopic images, annotations
- *Analysis*: modeling and sensemaking by combining data from multiple data files with specialized software
- *Bottleneck problem*: manually matching/merging/filtering data is extremely cumbersome and the problem is compounded by the difficulty finding the right data files

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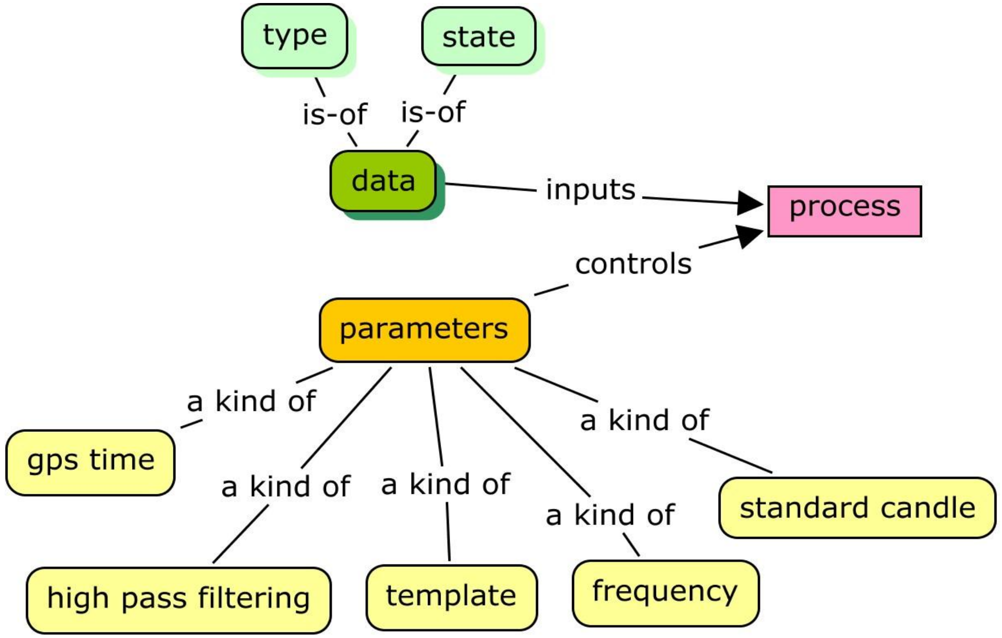
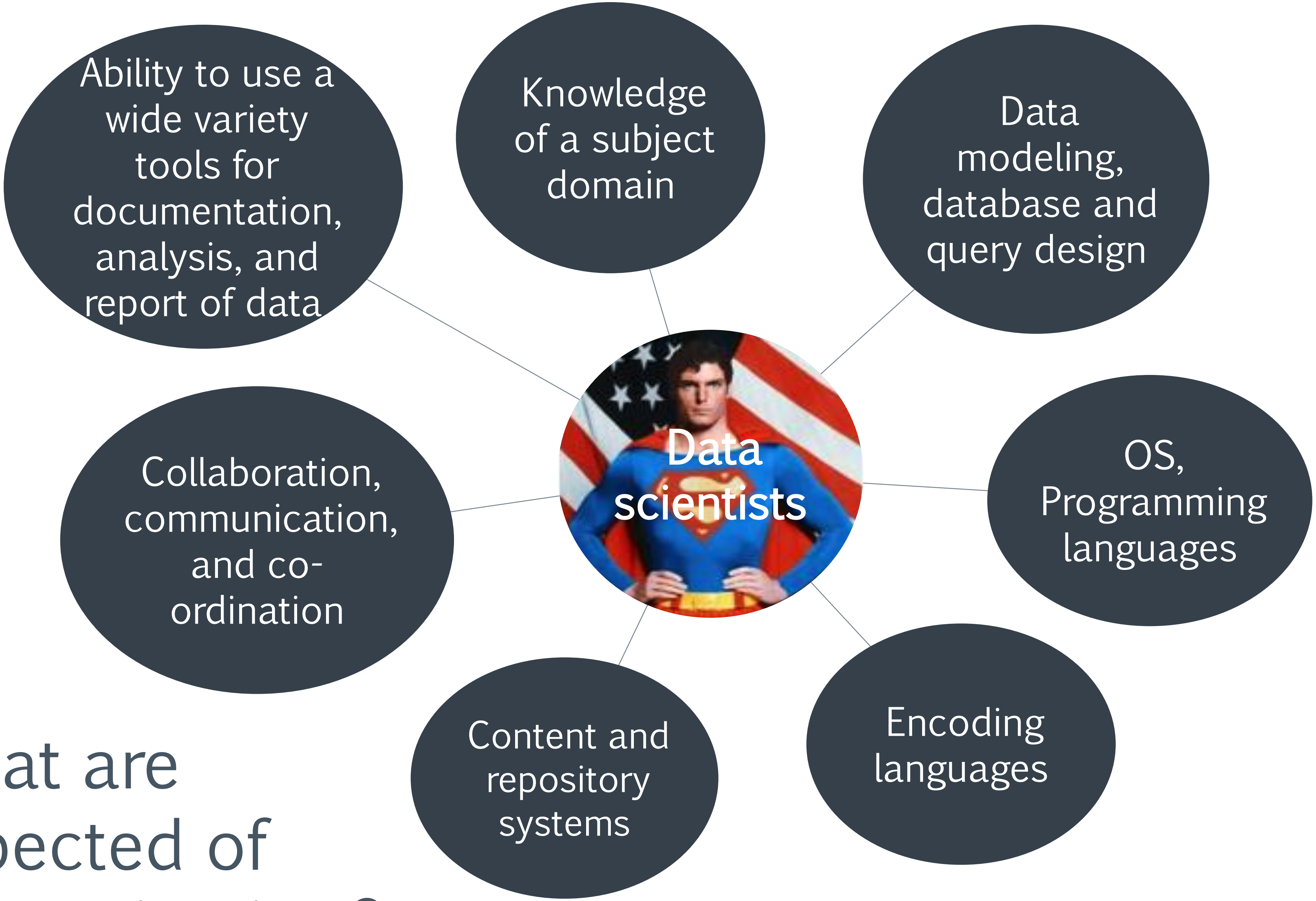
Story 2: highly automated workflows

- *Domain:* Astrophysics: gravitational wave detection
- *What's involved*: data ingestion from laser interferometers, raw data calibration and segmentation, workflow management, provenance
- *Data types*: streaming data from the laser interferometers, images
- *Analysis*: detection of "events"
- *Bottleneck problem*: tracking of data and processes and the relationships between them



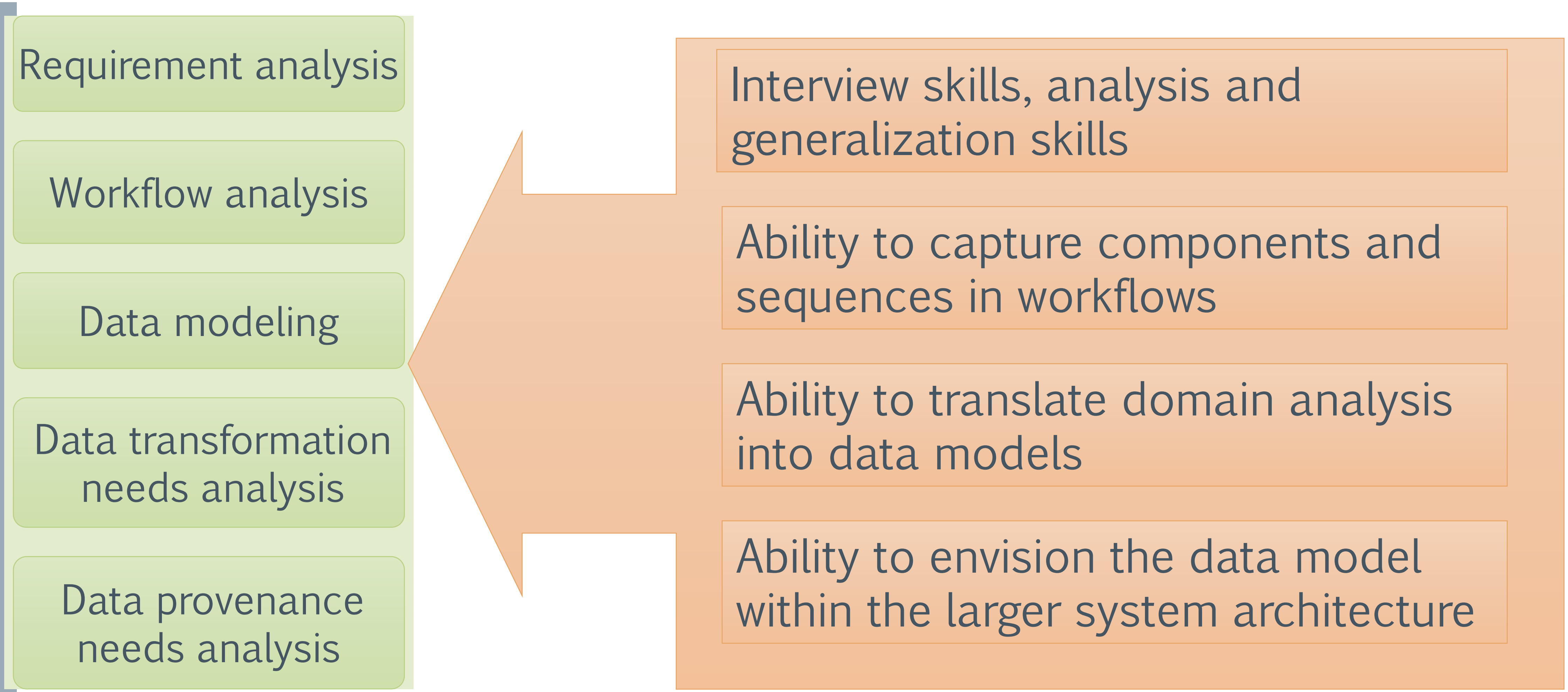


Data scientists

- Ability to use a wide variety tools for documentation, analysis, and report of data
- Knowledge of a subject domain
- Data modeling, database and query design
- OS, Programming languages
- Encoding languages
- Content and repository systems
- Collaboration, communication, and co-ordination

What are expected of data scientists?

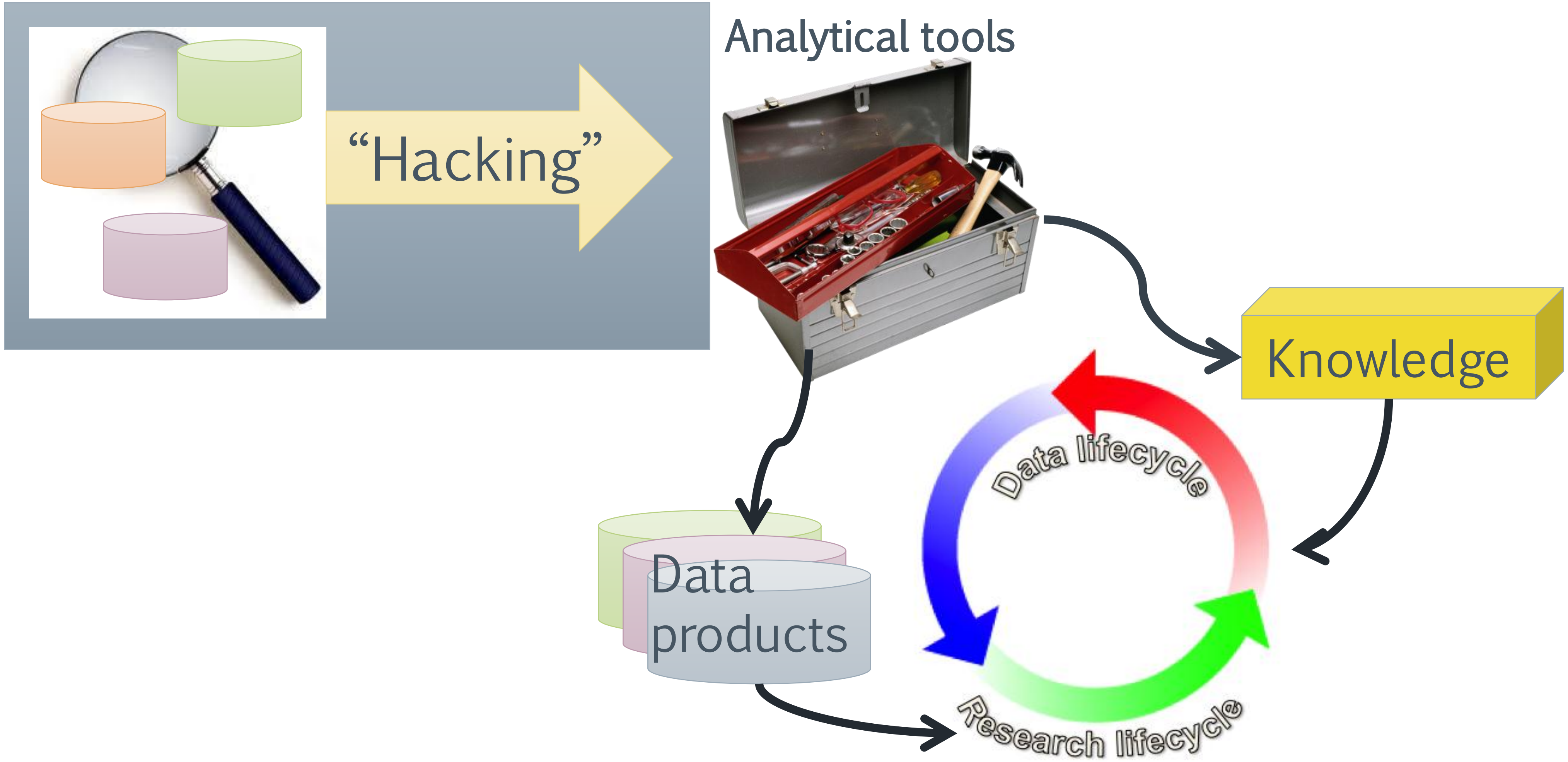
Analytical skills: domain modeling



- Requirement analysis
- Workflow analysis
- Data modeling
- Data transformation needs analysis
- Data provenance needs analysis

- Interview skills, analysis and generalization skills
- Ability to capture components and sequences in workflows
- Ability to translate domain analysis into data models
- Ability to envision the data model within the larger system architecture

Analytical skills: from data sources to patterns, relationships, and trends



"Hacking"

Analytical tools

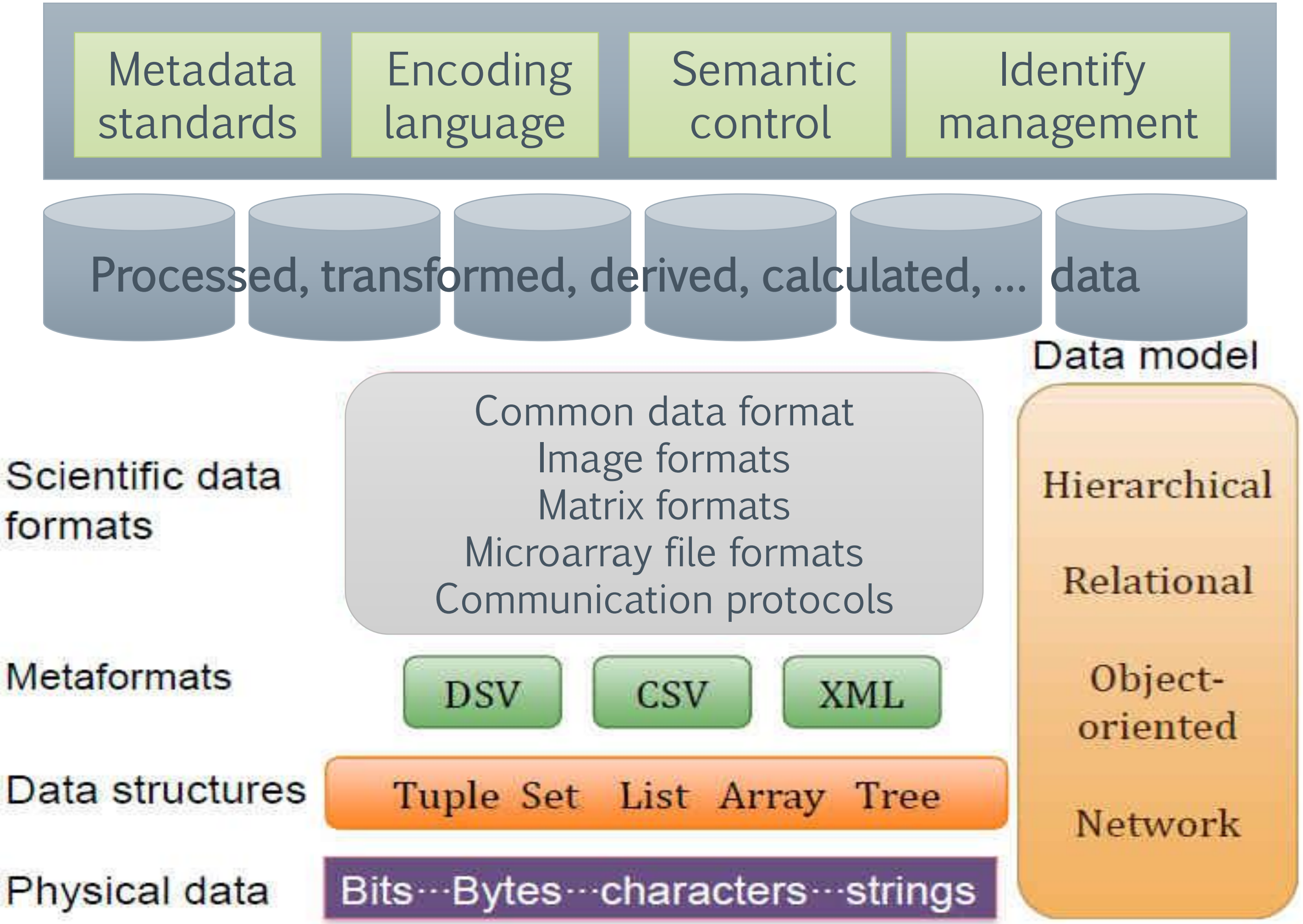
Knowledge

Data products

Data lifecycle

Research lifecycle

Data management skills: data lifecycle and infrastructural services



Metadata standards

Encoding language

Semantic control

Identify management

Processed, transformed, derived, calculated, … data

Data model

Hierarchical

Relational

Object-oriented

Network

Scientific data formats

Common data format
Image formats
Matrix formats
Microarray file formats
Communication protocols

Metaformats

DSV CSV XML

Data structures

Tuple Set List Array Tree

Physical data

Bits···Bytes···characters···strings

Infrastructural services

- Data source discovery
- Data curation
- Data preservation
- Data integration and mashup
- Data citation, publication, and distribution
- Data linking and interoperability
- …

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Technology skills with excellent communication skills

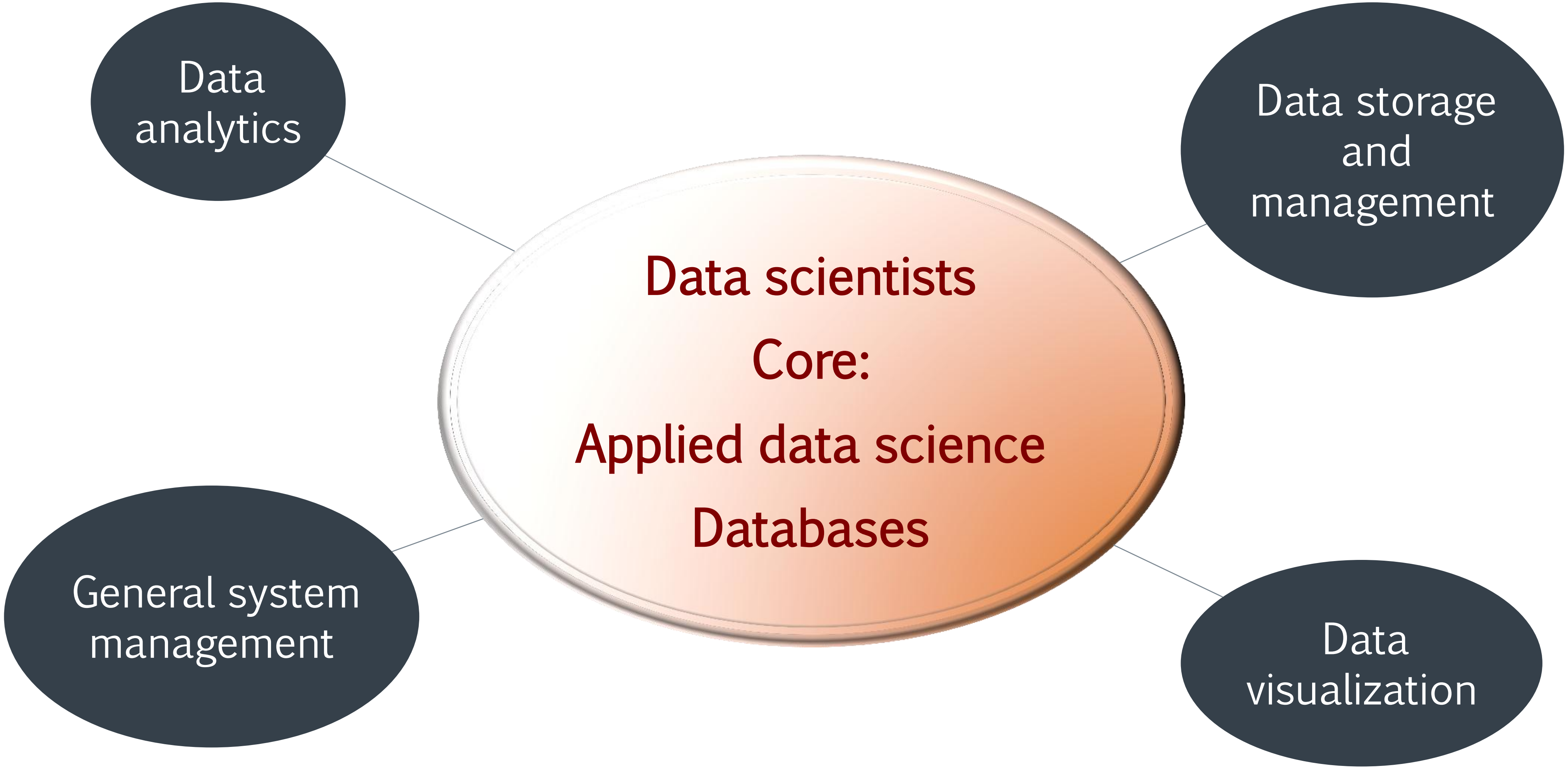
TECHNOLOGY SKILLS

- Operation systems
- Repository systems
- Database systems
- Programming languages
- Encoding languages
- Specialized programming

COMMUNICATION SKILLS

- Interviews
- "Ice breaking"
- Community building
- Institutionalization
- Stakeholder buy-in

No superman model for beginning data scientists



Data scientists

Core:

Applied data science

Databases

Data analytics

Data storage and management

General system management

Data visualization

The CAS in Data Science program at SU

- Required:
  - Data Administration Concepts and Database Management
  - Applied Data Science
- Elective:

Data Analytics

- Data Mining
- Basics of Information Retrieval Systems
- Natural Language Processing
- Advanced Information Analytics
- Research Methods
- Statistical Methods

Data Storage and Management

- Technologies for Web Content Management
- Foundations of Digital Data
- Creating, Managing, and Preserving Digital Assets
- Data Warehousing
- Advanced Database Management

Data Visualization

- Information Architecture for Internet Services
- Information Visualization

General Systems Management

- Enterprise Technologies
- Managing Information Systems Projects
- Information Systems Analysis

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What we learned from the program development

- Data science is a moving target with multiple focal points
  - Versions from statistics, computer science, and library and information science
- Skills vs. theories
  - Students are anxious to learn skills but not so interested in theories
  - Theories help build visions
- Sufficient hands-on time for technologies and tools
- Authentic learning through real-world data management projects

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Reconciliation of the two views of data science

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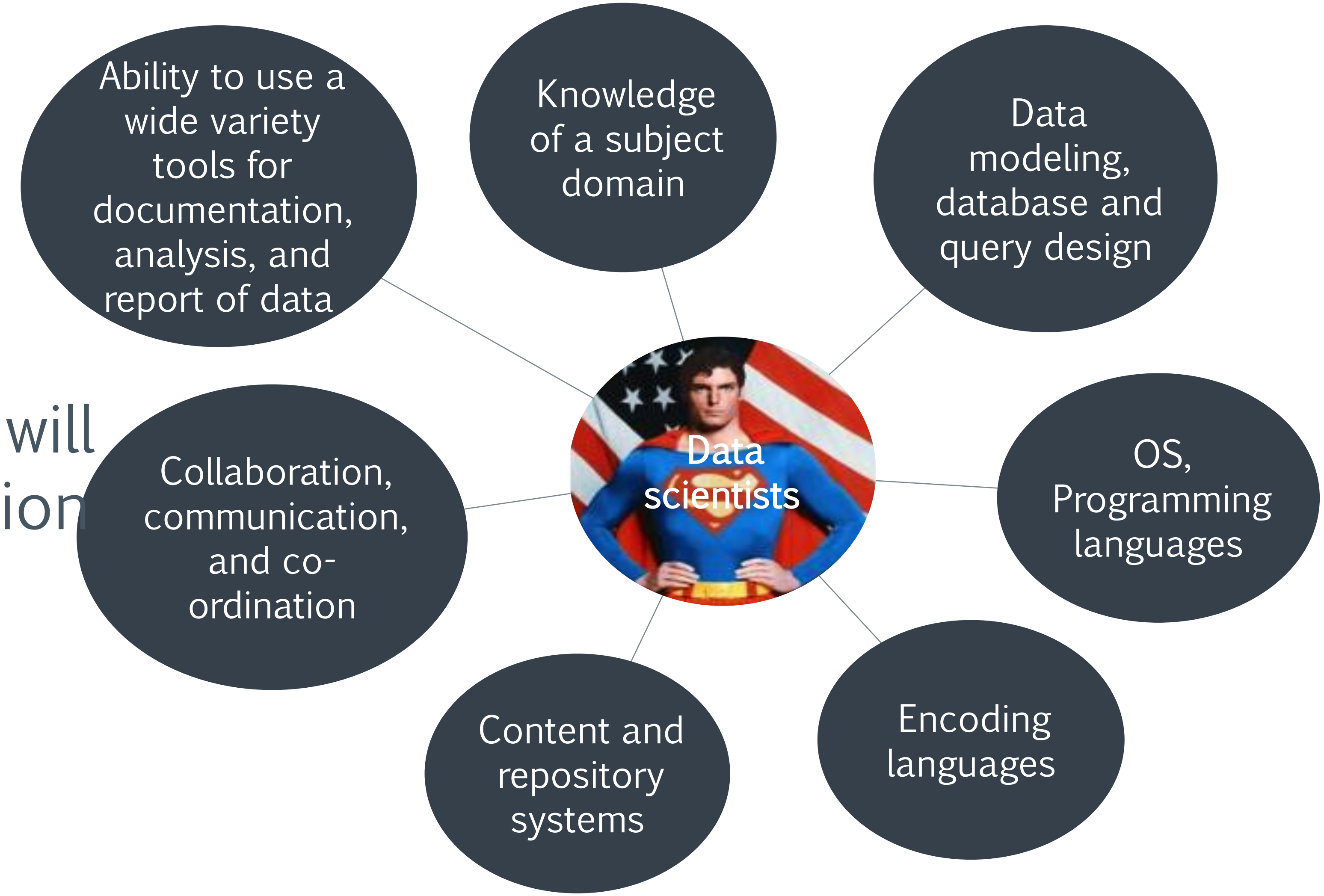
The iSchool's version of data science education

Eventually the iSchool data science program will build the foundation for super data scientists...



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eScience Librarianship Curriculum Project:
http://eslib.ischool.syr.edu/

INSTITUTE of Museum and Library SERVICES

Science Data Literacy Project:
http://sdl.syr.edu/

NSF

CAS in Data Science:
http://ischool.syr.edu/future/cas/datasci
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