Crafting a Minor to Produce T-Shaped Graduates

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Business-Higher Education Forum
About the Business-Higher Education Forum

The Business-Higher Education Forum (BHEF) is a membership organization of Fortune 500 CEOs, college/university presidents, and other leaders who collaborate to promote innovation and enhance US global competitiveness through its National Higher Education and Workforce Initiative.

BHEF Mission

• BHEF members collaborate to increase baccalaureate attainment and improve alignment between higher education and the workforce by creating undergraduate pathways to produce a diverse, highly-skilled talent pool to meet demand in emerging fields.

• BHEF convenes business and academic leaders, promotes effective undergraduate program design and development to create workforce solutions, and offers guidance to increase the impact on baccalaureate outcomes.

• BHEF facilitates peer-to-peer engagement by its members and inspires peer leaders to act.

Shapes the National Agenda for Business & Higher Education Collaboration through Convenings

Influences Practice & Policy through Research & Thought Leadership

Addresses Workforce Needs through Programmatic Initiatives
BHEF’s National Higher Education and Workforce Initiative (HEWI): Strategy

What are the supply challenges?
- Innovation and competition increasingly rely on new and emerging fields
- There is an increase in competition for talent
- Increased need to recruit and retain a diverse workforce

What is BHEF’s strategy?
- Deploy a model of strategic business engagement with higher education to shift from transactional relationships to strategic partnerships to develop talent ecosystems
- Create undergraduate career pathways that satisfy employer demand for a high-skilled workforce, especially for women, minorities, and veterans

Why does this strategy work?
- BHEF has conducted extensive research to understand the interventions and strategies that work best to support the success of undergraduate students
- BHEF has successfully implemented this strategy, beginning with cybersecurity at the University of Maryland
Strategic Partnership Implementation Process

The process that BHEF follows when evaluating, designing, and launching new programs in collaboration with higher education and business:

1. Job Market Landscape and Skills Analysis
2. Business-Led Ideal Candidate Profile
3. Academic Skills Mapping & Gap Analysis
4. Selection of Academic Credential to Pursue
5. Integration of High Impact Practices
6. Development/Feedback on Curriculum & Courses
7. Roll-out of New Program w/ Contd Engagement
8. Changed Hiring Practices
Elevating the Minor

For decades the minor has been a tool that allows students studying at post secondary institutions to pursue a secondary field of interest. Today, the minor can serve as a vehicle for preparing students for the workforce, integrating 21st century skills, and providing a credential that employers are demanding.

The WHY

- Minors are already embedded into the culture of most institutions
- Employers seek a recognized credential that they can hire to
- Colleges and Universities can add new minors with limited hurdles, such that the time to implementation can be quite rapid

The WHAT

- Minors can be used to ‘round out’ a students experience and intentionally develop T-shaped professional
- Allows students with deep expertise in a certain subject, particularly non-technical, to receive a credential that employers see as high-demand
- Crafted to integrate employer needs and experiential opportunities
- Often, few new courses need to be developed; just re-grouped and contextualized for the audience
Elements of the Ideal Minor

Regardless of the subject area, minors should be developed using a core set of design principles.

1. Pick subject areas that are high-demand and that employers feel a skills gap exists, such as data science or cybersecurity
2. Courses should be offered to cover:
   - An introduction to the field with hands-on learning
   - Technical content (required by all)
   - Interdisciplinary and applied content (students select based on interest)
   - A relevant semester-long applied learning experience
3. 21st century workplace skills should be intentionally embedded and evaluated; not taken as a siloed course
4. Embed real-world problem-sets, challenges, case studies, and interaction with employers throughout program
5. Link to student societies, competitions and professional associations to build sense of community amongst student peers
Data Science Provides a Remix Opportunity

Data Science is transforming education, business, society
• Through openness and remixing

**Openness: Open Data, Open Standards, Open Source Codes,**
• Open Source Development Processes, Reproducible Research,

**Remix Culture: To allow and encourage derivative works**
• By combining or editing existing materials to produce a new product

The Applied Data Science (ADS) Undergraduate Minor remixes
• Disciplines: Computer Science, Statistics, Math, Engineering, Science, Finance, Marketing, Genetics, Medicine, Physics, Sociology, Astronomy, etc.
• Students: Cross-disciplinary exposure to ADS and Domain Areas Expanding and diversifying students skill and tool sets
• Faculty, Departments, Schools: New connections outside of existing disciplinary structures
• Businesses: Traditional job categories, value chains and business lines, markets
• Society: Mobility of graduates, cross-generational interactions, societal solutions

Remix: Making Art and Commerce Thrive in the Hybrid Economy by Lawrence Lessig, 2008
Crafting the ADS Minor Requires Multiple Foci

Applied Data Science (ADS)
- Domain-based data science
  Applicable to multiple Domains
- Openness
- Collaboration
- Cyber security
- Ethics
- Reproducibility

Pedagogical Goals for ADS Courses
- Coding
- Inferential Statistics
- Exploratory Data Analysis
- ADS Data Science Research
- Modeling, Prediction & Statistical Learning

Constituencies
- Faculty, Departments, Schools
- ADS undergraduate students
- Graduate students
- Employers
- Society
- Change agent roles

Trajectories / Temporal Evolution Of
- ADS student
- University team research
- Collaborations,
  - Remixing Departments, Schools
  - Remixing of Undergraduate, Graduate Students,
    - Change agents in Business and Society

Open Data Science (ODS) Infrastructure.
- ODS Tool Chain
- ODS data packages
- ODS Virtual Desktops (VDIs)
- Statistical & Machine Learning
A Minor in Applied Data Science (ADS)

Datascience.case.edu/minor

Available in all schools of CWRU

• Case School of Engineering
• College of Arts and Sciences
• School of Medicine
• School of Nursing
• Weatherhead School of Management

Student demand is strong

In Domain Areas of Expertise

• Applied Data Science Practitioners
• Who have the Major expertise in particular Domains

Based in the Case School of Engineering

Data Science Major also being established

• In approval process now
ADS Minor Graduates Know ADS’s Essentials Elements

**Steps of data analysis**

1. Define the ADS questions
2. Identify, locate, and/or generate the data
   - Including defining the ideal data set and variables
   - Determining and obtaining accessible data
   - Cleaning the data in preparation for analysis
3. Exploratory data analysis
   - Start identifying the significant characteristics of the data and information it contains.
4. Statistical modeling and prediction
   - Including interpretation of results,
   - Challenging results, and
   - Developing insights and actions
5. Synthesizing the results
   - In domain context of domain
   - Writing this up.
6. Creation of reproducible research
   - Including code, datasets
   - Documentation and reports
     Which are easily transferable and verifiable

**ADS tools & application in domain area**

1. Data Management:
   - Datastores, sources, streams
2. Distributed Computing:
   - Local & distributed computing
   - Hadoop or other cloud computing
3. Informatics, Ontology, Query:
   - Including search, data assembly, annotation
4. Statistical Analytics:
   - Tools such as high level scripting languages
     - e.g. R statistics, Python, Ruby
The Domain Areas being developed include

**Engineering & Physical Sciences**
- Energy
- Manufacturing
- Astronomy

**Health**
- Translational
- Clinical

**Business**
- Finance
- Marketing
- Economics

**Domain areas added**
- as we go forward

**Synergy of Education**
- With Industry, Research, Society
Faculty involved in Applied Data Science Minor Committee

ADS Minor Based In The ADS Faculty

Representing Faculty From
• Departments & Schools
• Supporting the ADS Minor

Developing DSA Curricula & Courses
• New Cross-cutting and Domain specific courses
• Updating Syllabi for existing courses

Are defining the ADS Minor for approvals

DSCI Course Code Established
• For cross listing ADS Minor classes
• Among departments and schools

<table>
<thead>
<tr>
<th>Name</th>
<th>Dept./School</th>
<th>Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roger French</td>
<td>EMSE/CSE</td>
<td>Energy/Man</td>
</tr>
<tr>
<td>Gurkan Bebek</td>
<td>Bioinformatics/SOM</td>
<td>Health</td>
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<tr>
<td>Jim McGuffin-Cawley</td>
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<td>Man</td>
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<td>Alexis Abramson</td>
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<td>Mark Chance</td>
<td>SysBio/SOM</td>
<td>Health</td>
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<tr>
<td>Jagdip Singh</td>
<td>Design &amp; Innovation/WSOM</td>
<td>Business</td>
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<tr>
<td>Robin Dubin</td>
<td>Economics/WSOM</td>
<td>Economics</td>
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<tr>
<td>William Mahnic</td>
<td>Finance/WSOM</td>
<td>Finance</td>
</tr>
<tr>
<td>Jennifer Carter</td>
<td>EMSE/CSE</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>Jenny Brynjarsdottir</td>
<td>Statistics/MAMS</td>
<td>CrossCutting</td>
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</tbody>
</table>
The ADS Minor Curriculum

Covers the spectrum of learning to achieve domain area ADS expertise

The curriculum is based on five, 3 credit, courses

• Progressing from Level 1 to Level 5,

The courses are chosen to be both

• Cross cutting In fundamental ADS concepts  (Levels 1,2, and 4)
  such as scripting and statistics
• Domain area focused (Levels 3 and 5).

And to remix students

• Across the university and domains
• Across undergraduate and graduate populations
• Between ADS Minor and the Data Science Major (being developed)

<table>
<thead>
<tr>
<th>Domains =&gt;</th>
<th>Engineering &amp; Physical Sciences</th>
<th>Health</th>
<th>Business</th>
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<tbody>
<tr>
<td>5. Modeling &amp; Prognostics</td>
<td>ASTR 306</td>
<td>Trans. ADS SYBB 459</td>
<td>Clinical ADS SYBB 322</td>
</tr>
<tr>
<td>4. UG ADS Research</td>
<td>DSCI 352: team taught SYBB387</td>
<td></td>
<td>Marketing MKMR 308 MKMR 310</td>
</tr>
<tr>
<td>3. Exploratory ADS</td>
<td>DSCI 351</td>
<td>SYBB 311</td>
<td>SYBB 321</td>
</tr>
<tr>
<td>2. Inferential Statistics</td>
<td>OPRE 207, EPBI 431, SYBB 310 STAT 312R, STAT 201R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Data Science Programming</td>
<td>DSCI 133 DSCI 134</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Health: Clinical ADS SYBB 322, Finance BAFI 361
Business: Marketing MKMR 308 MKMR 310, Econ ECON 327
CWRU UG 2015 Choices Fair: 46 Students signed up

Applied Data Science
A New Undergraduate Minor

McKinsey Global Institute predicts a nationwide shortage of 140,000 to 190,000 workers with "deep analytical skills," and a deficit of 1.5 million managers capable of using big data analytics for actionable insights in their decision-making and predicts a 40 percent annual growth in global data and $300 billion in potential value-add of data analytics to the nation’s health care industry alone. Carver Inc. indicates that by 2015, 4.4 million information technology jobs globally will be created to support data science and analytics, generating 1.9 million IT jobs in the U.S. The U.S. government anticipates a shortage of about 50,000 qualified workers in health IT between 2010 and 2015. Healthcare companies are increasingly borrowing technology specialists from other industries.

Minor
Available to all CWRU undergraduate students


Steps of Data Analysis:
1. Define ADS questions
2. Identify, locate, generate data
3. Exploratory data analysis
4. Statistical modeling and prediction
5. Synthesizing results
6. Creation of reproducible research

Curriculum

Level 1: Data Science Programming
Level 2: Inferential Statistics
Level 3: Exploratory Applied Data Science
Level 4: Undergraduate Applied Data Science Research
Level 5: Modeling & Prognostics

Domain Areas

Domain areas available for minor concentration are:

- Engineering and Physical Sciences
  - Energy
  - Manufacturing
  - Astronomy
- Health
  - Translational
  - Clinical
- Business
  - Finance
  - Marketing
  - Economics

Faculty

<table>
<thead>
<tr>
<th>Name</th>
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</thead>
<tbody>
<tr>
<td>Roger Freligh</td>
<td>EMGRSSE</td>
<td>Energy-Cond.</td>
</tr>
<tr>
<td>Mark Zucker</td>
<td>EMGRSSE</td>
<td>Energy-Man.</td>
</tr>
<tr>
<td>Collin Dunning</td>
<td>EMGRSSE</td>
<td>Energy-Man.</td>
</tr>
<tr>
<td>John Shreiber</td>
<td>EMGRSSE</td>
<td>Energy-Man.</td>
</tr>
<tr>
<td>Thomas Carter</td>
<td>EMGRSSE</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>Chris Miller</td>
<td>EMGRSSE</td>
<td>Energy-Cond.</td>
</tr>
<tr>
<td>Savvy Ryancher</td>
<td>EMGRSSE</td>
<td>Energy-Man.</td>
</tr>
<tr>
<td>Gidi Scholtz</td>
<td>EMGRSSE</td>
<td>Energy-Man.</td>
</tr>
</tbody>
</table>

Industry Engagement in CWRU ADS Minor

Energy/Manufacturing
- Eaton
- FirstEnergy
- GE
- Sherwin Williams
- Timken

Healthcare
- Accenture
- Cleveland Clinic
- CPS
- GE
- KPMG LLP
- Medtronic
- Philips Healthcare
- Siemens
- University Hospitals
- IBM

Services
- Accenture
- GE
- Humana
- IBM
- Key Bank
- Medical Mutual of Ohio
- Teradata Corporation

Applied Data Science
A New Undergraduate Minor

Case Western Reserve University
Great Lakes Energy Institute
Open-Data-Science

**ODS Tool Chain**

Open-source Programming Languages
- Interpreted: low barriers to entry
- Community-based support

**R Project for Statistical Computing**

[Image of R icon]

**Python**

[Image of Python icon]

**Git distributed version control**

[Image of Git icon]

**Shared Repositories**
- For Codes
- For Projects
- For Classroom Materials

**ODS Infrastructure**

Common programming environment
- Across courses and students

**Virtual Machines (VDIs or VMs)**
- Default installs of ODS Tool Chain
- Simple Maintenance of VDI Software

**Accessible from anywhere**
- On any type of device

**Reduces time lost to software problems**

**Expose all to new software packages**
- Students & Faculty

**Hosted on our ADS ODS Server**
- Available to all ADS Students
Open-Data-Science Packages

Real-World Datasets / Data Science Problems

Hardcoat Acrylic Film Degradation

- You will work on degradation data from outdoor exposure of hard-coat acrylic films on polyester (PET) and urethane (TPU) substrates.

Photovoltaic Power Plant Time-Series

- You will work on real-world power plant time series data sets. Directly accessed from Energy CRADLE.

ADS Semester-long Research Projects

In DSCI Classes
- DSCI352: ADS UG Research
- DSCI353-453: Statistical Learning

Materials
- Degradation of Exterior Coatings
- PET Degradation
- Rapid Alloy Qualification
- Gloss Loss of PV Backsheets

Sustainability
- Climate Change in Alaska
- Fuel Cell Degradation

Energy
- PV Power Plant Time-series Analysis
- Data-driven Building Energy Efficiency

Image Analytics
- Automated SkyCamera Analytics of Clouds
- Facial Recognition for EVA Luminescence
- Image Analytics of Fluorescence

Fashion Analysis
- Goal: Try to read the consumer’s mind
- To predict changes in global trends,
- Using Twitter and web scraping of Vogue Magazine’s Twitter, Girl with Curves blog, and Retailers Forever 21, ASOS, Land’s End.

Image Analytics of Weld Beads
Minors, Data Science, and the T-Shaped Graduate

Minors provide a recognized, tangible vehicle for developing T-shaped graduates. Data science, an interdisciplinary field that could benefit most students, provides an ideal example of this in action.

The New Minor

• Recognizable credential in emerging fields where there is demand
• Provides technical skills to non-technical students
• Provides cross disciplinary skills to all students

Data Science

• Being explored as a new method of inquiry in the liberal arts
• Begins to address value of education with relevant skills employers can recognize, need, and are hiring for

Scaling Across the Country

• Replicable process and core elements all institutions can follow
• Provides minimal disruption to institutional infrastructure
• Develop new programs in concert with business and employers
Abstract

The undergraduate Minor offers undergraduates pursuing their baccalaureate degree an opportunity to develop a secondary focus as part of their normal course of study. The process to develop and award Minors is already embedded within the structure of many post-secondary intuitions. Minors can be used by academic institutions to offer curriculum and learning in emerging fields, such as cybersecurity and data science.

New minors, particularly those which are created to address gaps in existing degree areas and directly meet industry’s needs should be crafted as an intentional program of study, rather than a group of independent courses. These new minors should require experiential learning opportunities through an applied project, such as undergraduate research, internships, or a capstone project. Additionally, the required courses for the minor should be purposefully structured to embed 21st century workplace skills, such as critical thinking and communication. Graduates with this type of minor will be better prepared to enter the workforce and make an immediate contribution. Case Western Reserve University has developed this type of new Minor in Applied Data Science, which can serve as a national model.

The Applied Data Science Minor at Case Western Reserve University (CWRU) is available to all undergraduate students from any school across the campus. The program requires the students to advance through five levels: 1) Data Science Programming 2) Inferential Statistics 3) Exploratory Applied Data Science 4) Data Science Research 5) Statistical Learning; Modeling and Prediction. The ADS curriculum serves nicely as a generalized approach to many types of data science problems in today's society, where the challenge is to transform data to information. By having this tool in their arsenal, CWRU students will be able to capably differentiate themselves from other graduates in their domain and field. Furthermore, the ADS minor capabilities will open up doors across organizations that would otherwise be left undiscovered. The first students will graduate with the ADS minor in 2016.
SDLE Acknowledgements

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- Taylor Nguyen, Jacob Schimelman
- Elizabeth Hodges, Kevin Laverty
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- Nikhil Goel, Raj Shekar
- Marc Sahlan, Noah Sweet

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- Nicole Steinmetz, Hongping Zhao, Joao Maia, Mike Hore

SDLE Staff: Chris Littman, Rich Tomazin

Funding

International Energy Agency Photovoltaic Power Systems Programme

Office of Basic Energy Sciences
Materials Sciences and Engineering Division
Common Research Analytics and Data Lifecycle Environment

Energy CRADLE™

Network of Sub-Models
- Physical Models
- Statistical Models

Information & Significance
- Stressor - Mechanism - Response Network

Linked Data Ensembles
- Domain Meta-Data
- Provenance Meta-Data

Analytics
- Informatics
- Data Curation/Semantic Annotation

Tools/Knowledge
- Distributed Computing
- Data Analytics
- Statistics & Applied Math

Open Access
- Publications
- Best Practices
- Linked Data Sets

Mesoscopic Evolution Models
- Temporal Analytics

INPUT
- Real-World Experiments
- de Novo Data
- Lab-based Experiments
- Data Assembly

OUTPUT
- THE CLOUD
- Shared Terminology
- Ontologies
Degradation Science “Data Block” For Statistical Analytics

Using a Stress | Mechanism | Response Framework

Evaluations
Mechanistic Measures
Optical Absorbance
Fluorescence
FTIR
Raman
Microhardness

Performance Measures
Yellowness Index
Haze

Lab-Based Exposures

Real World

Candidates

Q1 Q2 QSun DH HF 1x 5x
2 SDLE Power Plants: 15 years of Time-series datastreams

SDLE PV Data Covers ~3.4 GW
Encompass 1.92% of Global PV Plants
• 787 PV Plant Sites
• 5638 PV Plants (Inv. & Modules)
• 60 PV Module Brands/Models
• 38 PV Inverter Brands/Models
• Single Modules to 265 MW plants
• Going Back Up To 15 years

Epidemiological PV Populations
• Of Time-series datastreams
• Real World Exposure Conditions
• Real World Systems
• Operating Over Real Time-scales
• Not Just Accelerated Lab Exposures

Population-based Studies Identify
• Statistically Significant Factors
• Controlling Lifetime Performance
• Real-world Degradation & Failure
Pair-wise Plot and Monthly Predictive Model: \textit{m4jmg2n}

Scatter plots of variable pairs
- bottom left corner: Histogram of each variable
- diagonal: Correlation coeff of each pair
- upper right corner: 

Same PV Module Brand

\textbf{Power Plant No. : m4jmg2n}
\textbf{Climate Zone :}
\textit{BSk Arid-Steppe-Cold}
\textbf{Date of operation 1999-10-27}

\textbf{Power Plant No. : fy9jhn6}
\textbf{Climate Zone :}
\textit{BSh Arid-Steppe-Hot}
\textbf{Date of operation 1999-10-27}