A BHEF CASE STUDY

CREATING A MINOR IN APPLIED DATA SCIENCE

Case Western Reserve University Engages Business Leaders to Produce T-Shaped Professionals

BHEF BUSINESS-HIGHER EDUCATION FORUM®

Creating Solutions. Inspiring Action.®

ABOUT BHEF

Now in its 38th year, BHEF is the nation's oldest membership organization of Fortune 500 CEOs, prominent college and university presidents, and other leaders dedicated to advancing innovative education and workforce solutions and improving U.S. competitiveness. BHEF's business and academic members collaborate in regions across the country to design and deploy education-workforce solutions in the high-demand and emerging fields that are so critical to innovation and national security. BHEF and its members generate insights from research, modeling, and regional projects, work to influence public policy at the national and state levels, and inspire other leaders to act.

TABLE OF CONTENTS

INTRODUCTION

THROUGH THE COLLABORATION of its business and higher education members, the Business-Higher Education Forum (BHEF) launched the National Higher Education and Workforce Initiative (HEWI) to create new undergraduate pathways in high-skill, high-demand fields such as data science and analytics. Data science and analytics must be integrated with T-shaped skills, such as critical thinking, collaboration, and effective communication, which are critical for all graduates entering the 21st century workforce. Knowledge of data science and analytics in recent years has become as fundamental as any other skill for graduates' career readiness. BHEF's Strategic Business Engagement Model with higher education addresses this demand by moving the two sectors from transactional relationships to strategic partnerships through five strategies:

1. **ENGAGE** corporate leadership;
2. **FOCUS** corporate philanthropy on undergraduate education;
3. **IDENTIFY** and tap core competencies and expertise;
4. **FACILITATE** and encourage employee, faculty, and staff engagement;
5. **EXPAND** the focus of funded research to include undergraduate education.

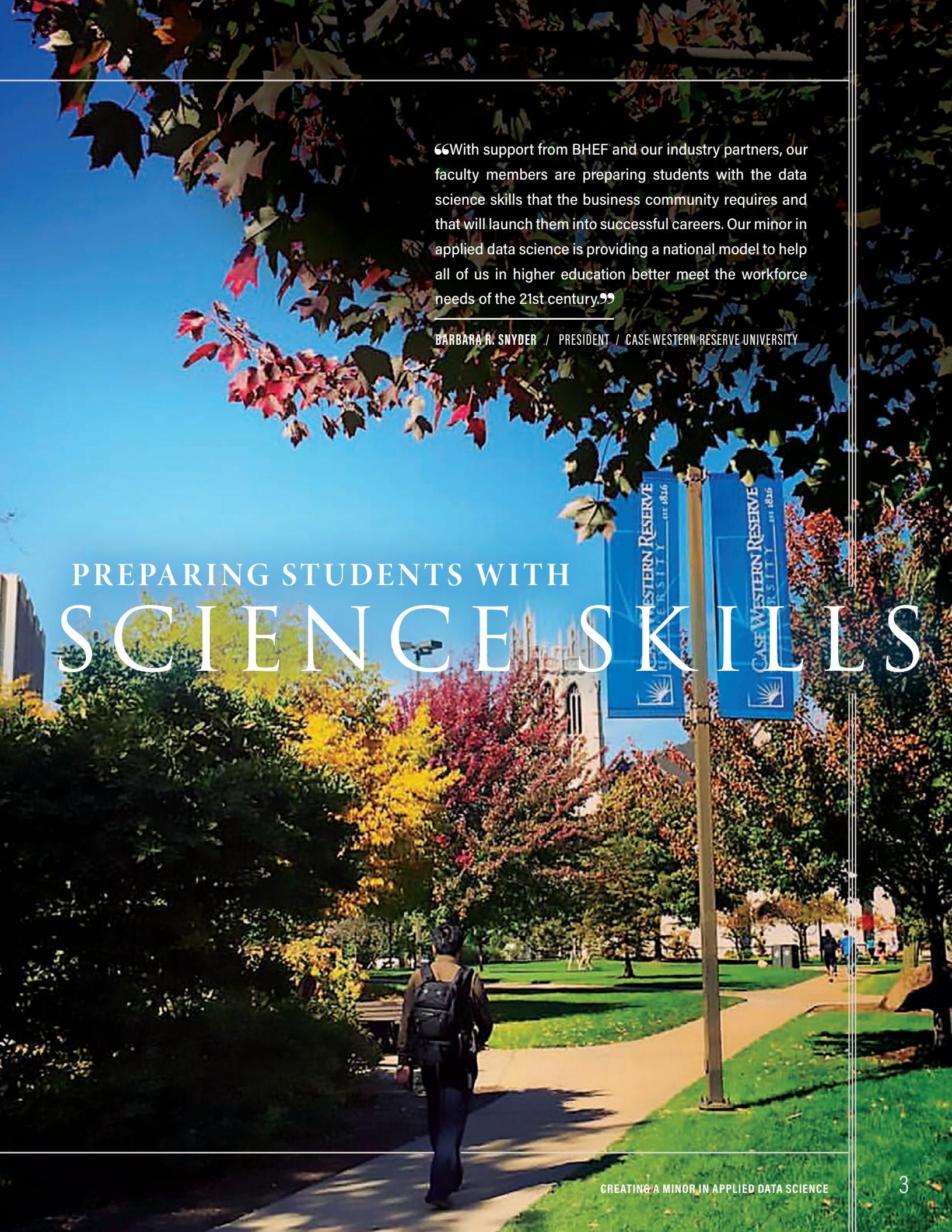
This case study examines how BHEF member Case Western Reserve University (Case Western Reserve) is integrating T-shaped skills into a minor in applied data science.

PROGRAM OVERVIEW

THE APPLIED DATA SCIENCE (ADS) MINOR AT CASE WESTERN RESERVE serves as a national model for undergraduate education in data science. Available to every undergraduate student across all schools at the university, this program of study requires experiential learning opportunities, embeds T-shaped skills, and allows students to master fundamental ADS concepts in their chosen domain area. From strong leadership engagement to funded undergraduate research opportunities, Case Western Reserve applied BHEF's Strategic Business Engagement Model to create a minor that responds to the fundamental need for data science in today's global business community.

BUSINESS PARTNERS

- Accenture
- Cleveland Clinic
- Eaton Corporation
- Explorys
- FirstEnergy Corporation
- General Electric
- Humana
- IBM
- KeyBank
- KPMG LLP
- Medical Mutual of Ohio
- Medtronic
- Philips Healthcare
- Sherwin-Williams Company
- Siemens
- Teradata Corporation
- Timken Company
- University Hospitals of Cleveland



> "With support from BHEF and our industry partners, our faculty members are preparing students with the data science skills that the business community requires and that will launch them into successful careers. Our minor in applied data science is providing a national model to help all of us in higher education better meet the workforce needs of the 21st century."
>
> **BARBARA R. SNYDER** / PRESIDENT / CASE WESTERN RESERVE UNIVERSITY

PREPARING STUDENTS WITH SCIENCE SKILLS

THE CHALLENGE

Respond to the increased demand for graduates with deep analytical skills.

COMBINING COMPUTING, DATA ENGINEERING, mathematics, statistics, and other disciplines, data science benefits businesses by revealing competitive advantages, customers' needs, new opportunities, and previously unforeseen challenges. In recent years, this interdisciplinary field, along with a movement toward open data science (i.e., an approach to data science using open-source tools), has started to transform global society. Organizations of all sizes increasingly rely on data science as critical to their core operations, yet statistics reveal a talent gap in the workforce. A 2011 McKinsey Global Institute (McKinsey) report predicted that "big data" would grow by 40 percent annually, through 2020 add $300 billion in value to the nation's health care industry, and have broad application in a variety of sectors. However, McKinsey also projected a nationwide shortage of 140,000 to 190,000 workers with "deep analytical skills" and a deficit of 1.5 million managers capable of applying big data analytics to their decision-making. Nevertheless, company-wide use of big data and analytics continues to grow rapidly as a critical priority of executives. McKinsey reported single-year increases in surveyed companies' use of big data and analytics to improve decision-making, research and development, and budgeting and forecasting of 17 percent, 14 percent, and 12 percent, respectively.

Higher education has been slow to respond to the increased demand for graduates with deep analytical skills. Most data science programs serve as post-baccalaureate training for students who have already acquired skills in analytical thinking, applied mathematics, and computer programming but lack the domain-specific knowledge required by companies. Moreover, of the programs that educate undergraduates in data science, most limit participation to science, technology, engineering, and mathematics majors in the final two years of college. The challenge for Case Western Reserve's faculty and administration was to create a new undergraduate program that would respond to the changing needs of business and offer data science courses beginning in the freshman year.

"The applied data science program at Case Western Reserve University is a unique asset to a university and a prime example of an evolving curriculum that keeps up with industry trends. Housing information and analyzing large databases to create models that can extrapolate and predict product performance can rapidly expedite the time to commercialize a product. Case Western Reserve's forward-thinking curriculum paired with strong business relationships allow students to be more marketable post-graduation and gain real-world application for enhanced understanding of classroom topics."

ALYSON REDFERN / GROUP LEADER / SHERWIN-WILLIAMS

THE SOLUTION

Initiate a data science workforce strategy and create a new undergraduate program.

IN 2013-2014, Case Western Reserve President Barbara Snyder served as BHEF chair. As part of her leadership role at BHEF, she conducted an internal institutional review of curricular needs and opportunities to engage business, industry, and external partners in addressing emerging workforce needs. BHEF proposed a collaboration with Case Western Reserve and its partners on a data science initiative through HEWI. In July 2013, Case Western Reserve and BHEF initiated a data science workforce strategy, and creation of the new undergraduate program began.

The developmental phase revealed innovative opportunities. A matrix of Case Western Reserve's peer institutions showed that data science was mainly targeted at the graduate level, located in computer science departments, and lacked common courses across programs. A data science industry roundtable, co-organized by BHEF, composed of representatives from the energy, health care, manufacturing, and services industries, provided insight into the characteristics of current hires and existing skills gaps, as well as suggestions for program implementation. Based on the deliberations of this roundtable, Case Western Reserve embraced the opportunity to define a core undergraduate data science program to be offered to students across the university.

The undergraduate minor proved to be an ideal vehicle to develop the new program from both a higher education and business perspective. For employers, the minor is a recognized credential of the technical and interdisciplinary skills essential for the 21st century workforce. For institutions, minors represent an existing academic structure that can be crafted to integrate employer needs and experiential opportunities. Additionally, while institutions will still likely need to create new courses, minors can often be implemented quickly because courses are generally regrouped and contextualized for a new audience. Because of these factors and strong Case Western Reserve leadership, the planning and approval process for the Applied Data Science (ADS) minor was completed within one year.

Launched in fall 2014, the ADS minor is available to all undergraduate students attending any Case Western Reserve school, including the Case School of Engineering (CSE), College of Arts and Sciences (CAS), Frances Payne Bolton School of Nursing (FPB), School of Medicine (SOM), and Weatherhead School of Management (Weatherhead). Students learn the essential elements of ADS, which include data management, distributed computing, informatics, ontology, query, and statistical analytics. They also learn how to conduct data analysis, from defining ADS questions to creating reproducible research. The current domain areas for minor concentration are business (including finance, marketing, and economics), engineering and physical sciences (including energy, manufacturing, and astronomy), and health (including translational and clinical).

The curriculum is composed of five three-credit courses that advance the student through five levels:

1. data science programming;
2. inferential statistics;
3. exploratory ADS;
4. undergraduate ADS research;
5. modeling and prognostics.

Levels 1, 2, and 4 allow the student to master fundamental ADS concepts, such as scripting and statistics, while levels 3 and 5 allow the student to achieve domain area expertise. In addition, level 4 provides students with the opportunity to conduct undergraduate ADS research in their domain area. Altogether, the curriculum meets the 15-credit requirement of a minor and encompasses the learning needed to achieve ADS expertise in a domain area.

The ADS faculty represent departments and schools from across Case Western Reserve. These include the materials science and engineering and

THE SOLUTION

mechanical and aerospace engineering departments at CSE; the astronomy and mathematics departments at CAS; the systems biology and bioinformatics department at SOM; and the design and innovation, economics, and banking and finance departments at Weatherhead. The faculty performed a key role in developing the ADS curricula, providing insight into existing courses to add the minor and creating new cross-cutting and domain-specific courses to fill any learning gaps. A data science course code (DSCI) for cross-listing ADS minor classes among the different departments and schools and the administration's effort to ensure faculty coverage for new courses facilitated implementation.

In aligning coursework with the global movement toward open data, Case Western Reserve employs an open-data-science tool chain to introduce students to the basic elements of data science. The first tool is R Project for Statistical Computing or, alternatively, Python, which are open-source programming languages. To gain comfort in programming, students also use an integrated development environment (IDE), which provides a single program rather than a group of unrelated tools, to develop software. For distributed version control, which synchronizes software revisions across each student's working copy of code without requiring a common network on a team project, Case Western Reserve uses Git and GitHub. Notably, Case Western Reserve distributes codes, projects, and other classroom materials through a shared Git repository rather than a typical learning management system such as Blackboard. These open-source tools are used throughout all the ADS minor classes.

To facilitate student learning, Case Western Reserve equips virtual desktop infrastructures (VDIs) or virtual machines (VMs) with the default open-data-science tool chain software. Faculty and students can remotely log into the VDIs or VMs, hosted on Case Western Reserve's ADS open-data-science server, on any device through cloud computing. This infrastructure streamlines the software side of program implementation, allowing for simple software maintenance and efficient exposure to new software packages. It also provides those less familiar with scripting with the opportunity to learn on their own time and at their own pace. Financial resources from Case Western Reserve's business partners helped make the open-data-science infrastructure possible.

Case Western Reserve's data science steering committee, which oversees the university's data science efforts, is composed of faculty representatives from across the university, including CAS, CSE, FPB, SOM, and Weatherhead. An information technology representative advises on hardware and software needs, and a corporate relations representative communicates with industry partners to discuss progress, secure donations, and receive feedback to further refine the program. The committee meets regularly to discuss and advise on how to promote and coordinate the data science initiative throughout the institution.

Employers frequently fund the students' research projects or offer summer internships. Students benefit from real-world application of their learning through large, industry-provided datasets and problems that markedly differ from the small and predictable datasets normally used for teaching. This allows students to explore topics such as degradation science (study of the degradation of energy materials over time) and photovoltaics (conversion of solar energy into direct current electricity using semiconducting materials) through a real-world lens. Often, industry contributions are open-source data from partners who previously funded Case Western Reserve research projects. The university's Solar Durability and Lifetime Extension (SDLE) Center, a world-class research center dedicated to lifetime and degradation science, also is a key resource for student research projects. Case Western Reserve faculty are encouraged by the responsiveness and cooperation of their industry partners in supplying resources to their courses.

T-SHAPED SKILLS

Opportunities to develop T-shaped skills are integrated throughout the ADS minor curriculum. Students master core academic content in fundamental ADS for their chosen domain area by advancing through the five levels while developing open data skills. Real-world datasets and problems supplied by industry partners train students to think critically, analytically, and creatively in response to complex business issues.

Students are mixed across domains and degree programs. Mainly in levels 3, 4, and 5, courses combine students from a variety of domains, including psychology, genetics, finance, and marketing, as well as from the undergraduate and graduate populations. In fall 2016, Case Western Reserve expects to mix students in the ADS minor with those in a forthcoming data science major for the first-level programming course and the fourth-level research project. These mixing opportunities enable peer learning and prepare graduates for their future career environments, working with colleagues across disciplines and levels of expertise to achieve professional success.

The semester-long research project allows students to develop a range of T-shaped skills. In teams, students identify a project under the guidance of a domain expert professor. Students then apply their knowledge of data analysis and regularly report to the class on their projects, revealing the similarities and differences in data science approaches in different domains. Although only required in level 4, undergraduates can choose to pursue semester-long research projects in levels 3 and 5, which had previously been required for their graduate student peers, providing a unique example of self-directed learning in the program.

INSIGHTS

EMPLOYERS BENEFIT FROM UNDERGRADUATES WITH DATA SCIENCE SKILLS

Data science provides actionable insights that improve decision-making and stoke innovation in a wide range of organizations, including business, government, scientific and research organizations, and cultural institutions, as well as organizational functions, including operations, marketing, and communications. However, most organizations struggle to transform data into the type of business intelligence that is useful for decision-making because they lack employees who can apply data science to their domains. Through partnerships that instill such skills at the undergraduate level, businesses develop flexible and progressive talent, which can affect positive change and build significant competitive advantage.

DATA SCIENCE PROMOTES AN INTERDISCIPLINARY EDUCATION

Data science skills that cut across academic disciplines, domain-specific skills, and T-shaped skills such as critical thinking, communication, collaboration, and problem solving can be developed through an interdisciplinary minor. Faculty from multiple departments can work together to enhance existing or create new cross-cutting courses. Students who acquire these skills will meet the expectations of employers, regardless of sector, that are recruiting individuals who can apply data science tools in specific domain areas.

BUSINESSES VALUE STRATEGIC RELATIONSHIPS WITH HIGHER EDUCATION OVER TRANSACTIONAL ONES

Critical engagement from business leaders eased the challenge of creating the minor. Business engagement took many forms, including the data science industry roundtable, real-world datasets, program feedback, internships, and funding. Case Western Reserve learned that its industry partners prefer a collaborative rather than a transactional relationship—requesting that students work with them to solve industry problems instead of simply providing an answer, so that their scientists gain exposure to new data science methods. Cultivating those relationships has helped Case Western Reserve maintain strong business connections for continued support and engagement in the program.

MINORS FORMED USING A CORE SET OF DESIGN PRINCIPLES ARE AN IDEAL VEHICLE FOR DISRUPTION

Case Western Reserve, together with BHEF, identified five steps for creating the ideal minor:

1. Select a subject area that addresses a skills gap such as data science or cybersecurity.
2. Offer courses that provide a hands-on introduction to the field; cover technical, interdisciplinary, and applied content; and offer an experiential learning opportunity.
3. Structurally embed T-shaped skills such as critical thinking and effective communication.
4. Contextualize learning through real-world problem sets, challenges, case studies, and interaction with employers.
5. Build a sense of community through opportunities such as student societies, competitions, and professional associations.

Students benefit from this strategy because the minor provides a structured program of study rather than a set of independent courses. Employers benefit because they can seek a recognizable credential in their hiring process. Higher education institutions benefit because they can adapt the minor to respond to rapidly changing markets, sectors, and skills.

OPEN-SOURCE DATA AND TOOLS ADDRESS BIG DATA CHALLENGES

The challenges of working with big data include adequate storage, ownership, and privacy and security. Case Western Reserve addressed these challenges by embracing the open data movement, which promotes data that are freely available without restrictions. Aligned with this movement, Case Western Reserve uses the open-data-science tool chain, open-data-science infrastructure, and open-source data provided by industry partners to overcome concerns regarding the capacity, control, and protection of data in the ADS minor. Open-source distributed version control systems, such as Git, also facilitate the type of decentralized research projects that students engage in with business because data can be shared without a common network.

EARLY RETURNS

THE FIRST STUDENT WITH AN ADS MINOR graduated in spring 2016, and Case Western Reserve expects many more graduates in the future. Early indications of the program's success can be observed through the career trajectories of former students who took data science courses during the first year of implementation. According to supervisors at their new companies, these students exhibit extra flexibility in moving from one department to another, a quality valued by graduates and employers alike. They also serve as nonthreatening change agents because they impart new data science methods to their more experienced counterparts.

Building on the success of the ADS minor, Case Western Reserve is developing additional data science programs. Recently approved to launch in the fall of 2016, a new data science major, the BS in data science, will complement the minor. Rather than teaching students how to use and apply data science in domain areas, this major program will teach students how to design and develop new and innovative data science strategies and tools. Each senior will conduct a year-long capstone project for presentation at one of Case Western Reserve's campus-wide events.

Case Western Reserve plans to develop a post-baccalaureate certificate program in data science for industry personnel interested in retraining. In addition, Case Western Reserve already provides a variety of data science opportunities at the graduate level, including a master's degree track in health informatics at CSE, an MS or PhD in systems biology and bioinformatics at SOM, and master's level nursing informatics courses at FPB. Findings from the data science industry roundtable, along with unexpectedly strong student enthusiasm for the ADS minor, catalyzed this growth in programs.

Case Western Reserve has expanding its data science initiative to the global arena through an agreement with Tohoku University in Sendai, Japan. During a Data and Life Science Collaboration and Symposium hosted by Case Western Reserve, leaders of both universities signed a collaboration agreement focused on research and student exchanges. The agreement aligned with Tohoku University's desire to incorporate data science into its International Joint Graduate Programme project under the Top Global University Project, which aims to improve Japan's global outreach in education and research. The universities look forward to further developing this partnership.

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ACKNOWLEDGEMENTS

BHEF would like to thank Donald Feke, Roger French, and Christopher Littman for providing detailed information and insights about the development and implementation of the data science minor and major at Case Western Reserve University.

This work was funded by the William and Flora Hewlett Foundation. The deeper learning line of inquiry is a critical element of BHEF's work to strengthen partnerships between business and higher education in high-skill, high-demand fields.

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