BASICS

Business and Science: Integrated Curriculum for Sustainability

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NSF · Bentley University · Northern Illinois University · Wittenberg University · SERC · Oregon State University

Title: *Collaborative Research: Broadening the Fusion of STEM and Business Curricula in Undergraduate Sustainability Education*

Award: $2.1 Million, National Science Foundation (NSF-IUSE)

IUSE- Improving Undergraduate STEM Education
SERC- Science Education Resource Center at Carleton College

Faculty Perspectives

Curriculum Development

Student Learning

Research Question:
Can an innovative model of collaborative transdisciplinary sustainability curriculum development – led by STEM and business faculty – better prepare a 21st century workforce to address the wicked problems of sustainability in a global economy?

Vision: Fundamentally transform the way institutions of higher education support transdisciplinary curriculum development.

Assess impact on student learning and faculty perspectives

Wicked Problems

Problems difficult to formulate and impossible to “solve” because of incomplete, confusing, or contradictory information and involving innumerable stakeholders with conflicting perceptions, needs, and values. (Churchman, 1967)

Research Framework

Meeting the SDGs for a growing global population, in the face of natural resource challenges, all situated within the super-wicked problem of climate change, requires reshaping the way we educate the next generation of decision-makers.

Aim - bring a diverse group of STEM and business faculty to:

1

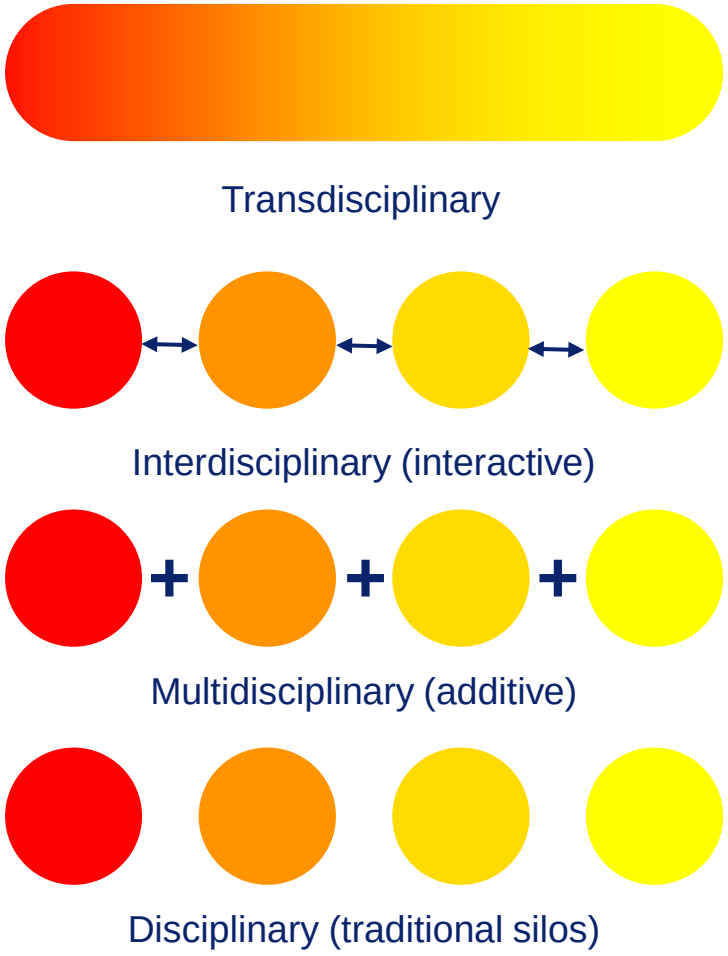
Develop course modules that introduce complex and transdisciplinary sustainability problems;

2

Create a “common” exercise that introduces the problem and links the disciplines to central theme;

3

Apply discipline-specific content in each course for context while teaching disciplinary concepts.



Transdisciplinary
Interdisciplinary
Multidisciplinary

"[Transdisciplinary thinking] has high aims of reconstituting and rearranging the nature of disciplinary knowledge…through fusion across arbitrary intellectual boundaries"

Stock and Burton (2011)

Diagram credit: UTS Business School, Anthropocene Transition Project


4. Compare and contrast the social, health, economic, and environmental equity implications of a linear and a circular economy.
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5. Gallery walk flexibility, timing, questions, etc.
Bethany
Furkan
Resources and tools for LLCs (SLO maps)


Revisions in Smaller Groups
BASICS Cohort 2 Common Exercise MUFAL
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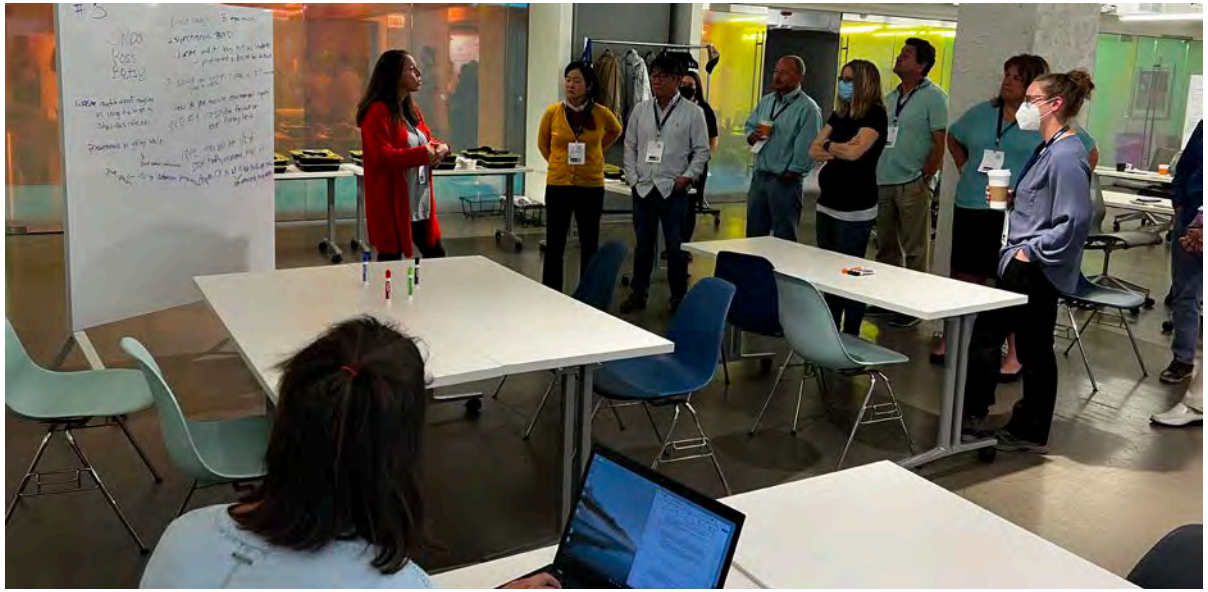


BASICS TEAM

Biology, Geology, Natural & Applied Sciences, Math/Statistics

Jennifer Bell
Megan Brown
Melissa Lenczewski (PI)
Wesley Swingley
Chit Wityi-oo
Joel Gimbel

Anthropology & Art/Design

Rebecca Houze
Emily McKee

Economics, Public Policy and Public Health

Tomoyuki Shibata
Thomas Skuzinski
Anna Klis

Marketing, Business & Management, Entrepreneurship

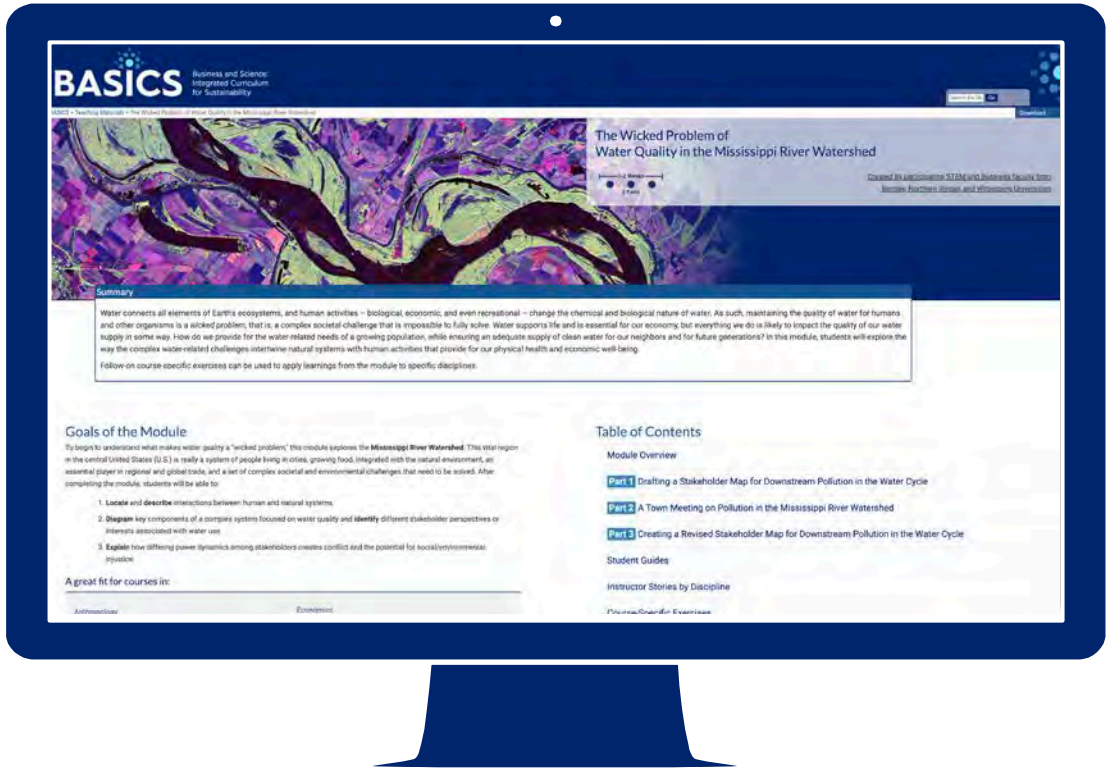
Bethany Cockburn
Christine Mooney (PI)
Bart Sharp
Furkan Gur
Elina Tang

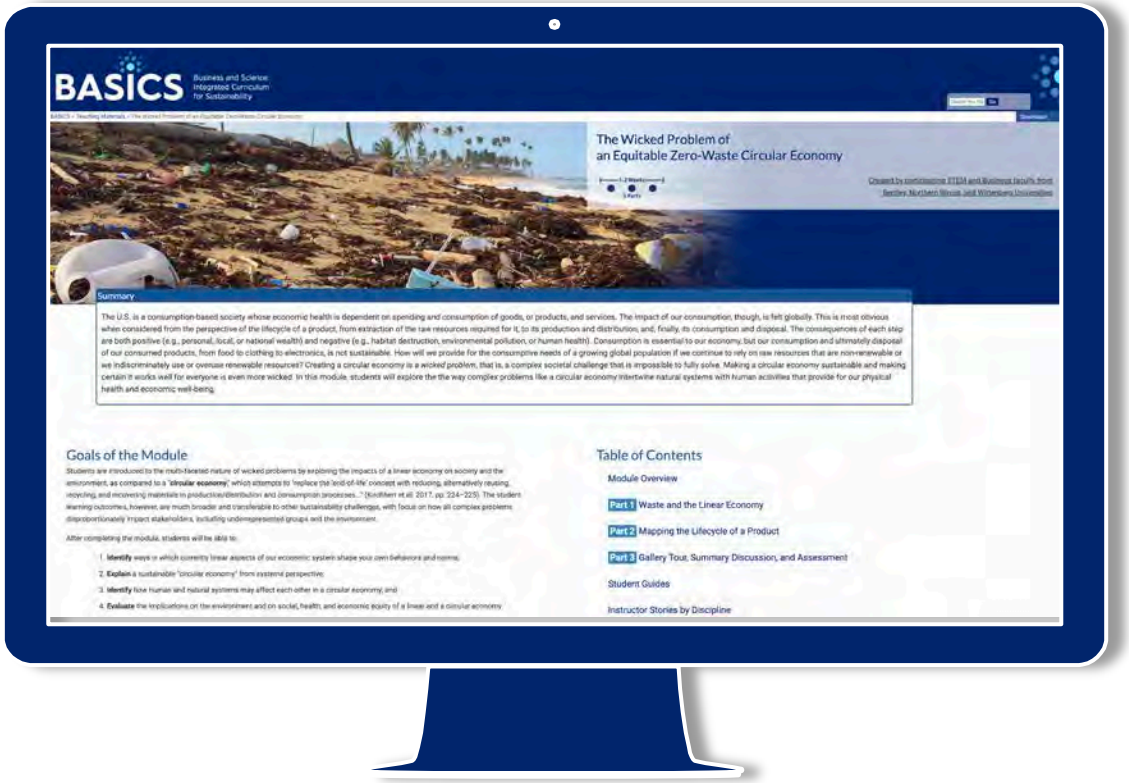
Engineering and Engineering Technology

Nicholas Pohlman
Theodore Hogan
Kevin Martin

Innovative Curriculum Process

- Backward Design- Start with SLOs
- Develop the curriculum (4 faculty each 3 institutions, ½ STEM/Business)
    1. Address one or more SDGs;
    2. Develop student ability to address transdisciplinary wicked problems;
    3. Improve student understanding of the nature and methods of science and business and how they interact;
    4. Include opportunities for students' analyses of authentic data and cultural and ethical perspectives; and
    5. Incorporate systems thinking across the curriculum.
- Iterative Process- Tried it, revised it, and then tested it again
- Developed two modules- Next slide
- Cohort 3 and 4
    - Testing of curriculum with other faculty





Two Curriculum Include:

- Curriculum Module (1-2 weeks of a course)
  - Online and in person
  - Slides, handouts, assessment, student guides, data
  - General Education to 400 Level
- Course Specific Exercises
- Instructor Stories

Courses Where BASICS Modules Have Been Used

Accounting Senior Capstone
Basic Marketing
Biological Fate of Drugs
Business Analytics
Business Writing
Chemistry of Sustainable Products
Cultural Anthropology
Diversity, Equity and Inclusion in the Marketplace
Ecology
Economics and Society
Elements of Environmental Health
Energy Alternatives
Energy and the Environment
Entrepreneurship and Business Model Designs
Entrepreneurship, Innovation and Sustainability
Environment in the Social Sciences and Humanities
Environmental Communication
Environmental Geology
Environmental Health
Environmental Science and Sustainability
Environmental Studies: Physical Sciences
Environmental Studies: Water Quality
Federal Taxation
Financial Reporting and Analysis
Freshwater Ecology
Geomicrobiology
Social Entrepreneurship
Herpetology
Human Biology
Innovation, Social Equity and Entrepreneurship in Media
Intro to Wildlife
Intro to Environmental Economics
Managerial Accounting
Managerial Negotiations
Managing a User-Centered Design Team
Managing Effective Organizations
Marketing and Operations Fundamentals
Marketing Management
Mental Health Practice
Natural Resources & the Environment
Pollution Prevention and Sustainable Production
Principles of Geology
Principles of Microeconomics
Race and Racialization at the U.S.-Mexico Border
Science in Environmental Policy
Science of Sustainability
Social Media Marketing
Strategic Management
Water Quality
Wind Energy

Impact on Student Learning

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Wicked Problem 1: Mississippi Watershed

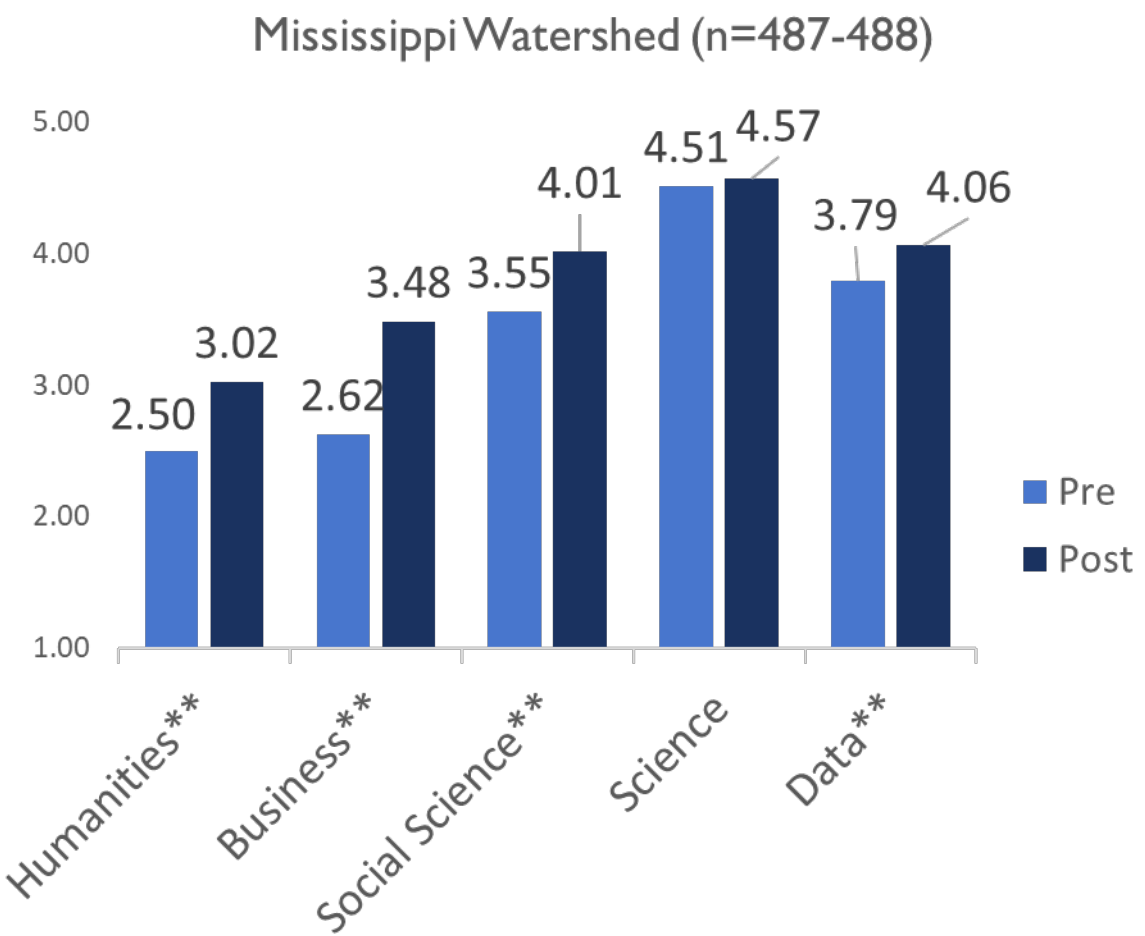
- Suppose that you were going to address the problem of nitrogen pollution in the Mississippi River watershed. Please indicate how important you think it would be to draw from expertise in each of the following fields in order to solve this problem.

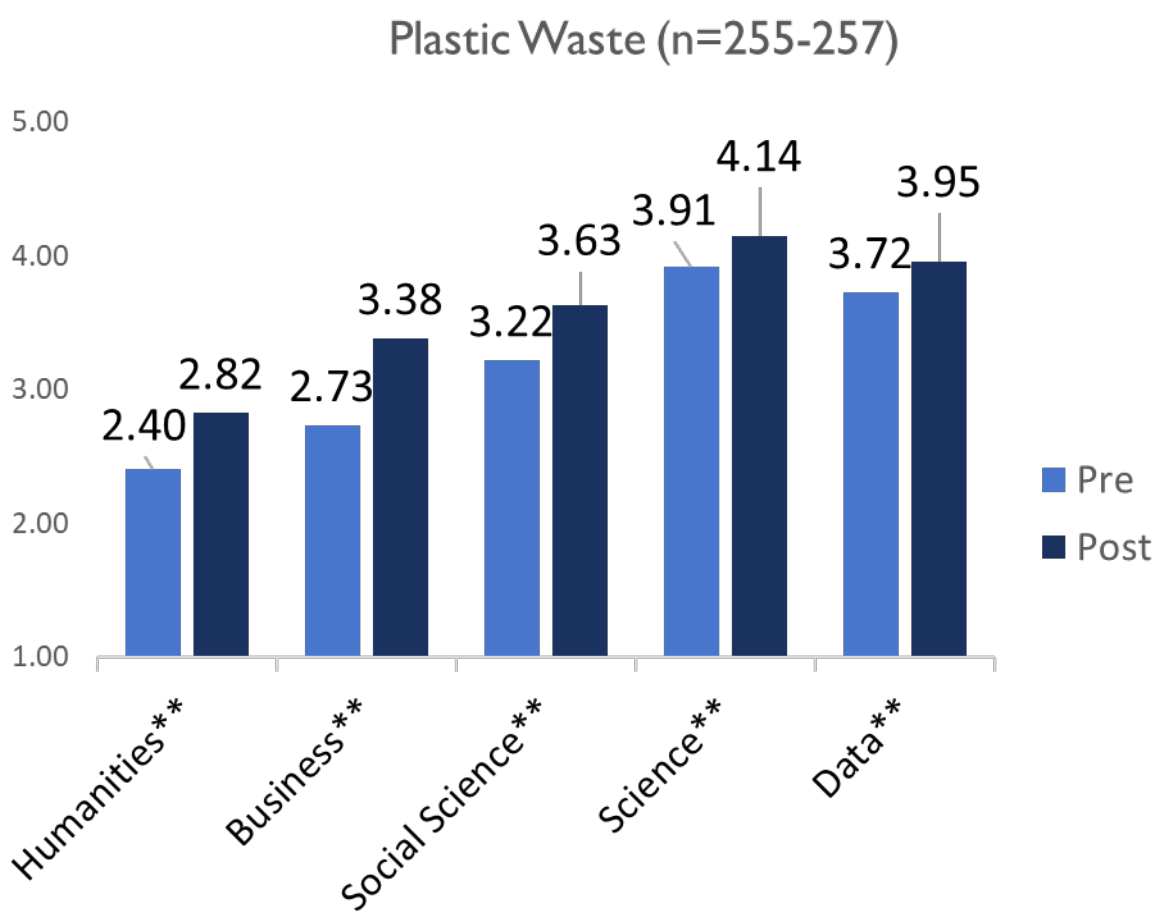
Wicked Problem 2: Plastic Waste

- Suppose that you were going to address the problem of plastic waste and that only a small fraction of plastic is effectively recycled. Please indicate how important you think it would be to draw from expertise in each of the following fields in order to solve this problem.

1 to 5 scale: Not important, Slightly important, Moderately important, Important, Very important

Students completing the Mississippi Watershed module in a course





1 to 5 scale: Not important, Slightly important, Moderately important, Important, Very important

**Highly statistically significant p<.001

RISC Survey: Benefits Interdisciplinary Learning

"Please rate how much learning you gained from each element you experienced to date in this course"

Statement	Cohort 1	Cohort 2	RISC
Learning that disciplines may approach problems in difference and sometimes conflicting ways (n=525: 510)	4.0	4.0	3.8
Attempting a complete understanding of a complex problem (n=524; 511)	3.9	3.9	3.65
Working on a problem that requires integrating ideas from two or more disciplines (n=525; 507)	3.9	3.97	3.5
Learning to find similarities and differences between disciplines or fields of study (n=525; 508)	3.8	3.8	3.5

1 to 5 scale: None or very small gain, Small gain, Moderate gain, Large gain, Very large gain.

Compared to National Sample from RISC survey 2016 (n=3,506).

Impact on Faculty Change

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Highlights: Faculty Motivations & Barriers

Motivations

- Professional development needs
- Improving pedagogy/learning
- Interest in sustainability

Barriers

- Increased time and workload
- Fear working outside normal disciplinary boundaries, lack of departmental and institutional recognition (e.g., in P&T)
- Perceive work not considered high (enough) priority by administration
- Experience tensions around disciplinary norms, practices, and language, suitability of the curricula, and confidence teaching it

Implications from Research: Role of Administration

- Help motivate and support faculty with respect to this very complex work
- Key roles in creating and reinforcing policies around teaching innovations
- Launch/sustain cross-disciplinary collaborations; provide resources such as course releases or stipends and teaching awards
- Alleviate concerns for operating outside normal disciplinary and organizational rules by influencing faculty evaluation policies and practices (revisions to teaching evaluations, frameworks and training around P&T review)
- Identify, develop and empower faculty leaders in their teaching

Oregon State University

Lessons Learned To-Date

1. Transdisciplinary collaboration can work.
2. The BASICS method for developing a common exercise is challenging, exciting, and relatively “easy.”
3. Convergence on how to frame the wicked problem is difficult and requires top-down support.
4. The iterative, collaborative process can be messy but is both necessary and transformational.
5. Students and faculty benefit from the approach.

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Next Steps

NextGen BASICS Leaders

NSF-IUSE
ICT Level 2 ($2M)
July 2024

A. Bentley, NIU & Wittenberg

B. Three additional institutions

Institutional Scaling and Capacity-Building

Northern Illinois University

wittenberg UNIVERSITY

NSF-IUSE and Internal and/or External Funding (Private Foundations)

Growing the Network and Broadening Reputation

Phase 1: NSF-IUSE ICT Level 2

Phase 2: Monetizing the BASICS model
e.g., Aspen Institute Fee-based Services

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This material is based upon work supported by the National Science Foundation (NSF) under Grants #1914906 (Bentley University), #1914909 (Northern Illinois University), and #1914913 (Wittenberg University).

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Integrated Curriculum
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Additional Slides

Ultimate Goal	A Sustained Cultural and Institutional Transformation in Higher Education that Prepares a 21st Century Workforce to Address the Wicked Problems of Sustainability				
Long-term Outcomes	Achieving Cultural Change at Participating Instututions			Long-term Metrics	• # Faculty teaching modules • # Courses with modules • # Students taken courses with modules • # Transdisciplinary majors/minors
	Broader Adoption of Transdisciplinary Modules at Participating Instututions				
	Developing Systems Thinking to Help Address Wicked Problems				
Intermediate-term Outcomes	Successful Adoption of Modules Beyond LLCs	Broad support for transdisciplinary education from Administration	Best Practices for Transdisciplinary Education Established	Intermediate-term Metrics	• # Faculty teaching modules • # Courses with modules • # Students taken courses with modules • # Transdisciplinary majors/minors
	Successful Development of Modules	Successful Dissemination of Modules	Students awareness of & exposure to wicked problems		
Short-term Outcomes and Activities	Presentations at Disciplinary Conferences	Website & Online community developed	Assessment & revisions of modules	Short-term Metrics	• # Presentations • Development of a website • Assessment of student outcomes
	Interactive, multi-day facilitated workshops	Development of Transdisciplinary Modules	Admin Engaged in Program Development		• # Multi-day workshops • # Transdisciplinary modules • # Administrators engaged
	Institutional Partners Established	Science and Business Faculty Recruited	Local Learning Communities Established		• Three different institutions • 7 PIs • # LLCs
Proof of Concept	Sustainability Course Exercise Developed & Assessed			Results	Transdisciplinary faculty learning and development of a network of researchers at the intersection of STEM and business


03:17:55
Speaker
Wesley Swingley
Dave Szymanski
Zoe Wagner
Cindy Lenhart
Ted Hogan
Sarah Fortner
Anna Klis
Ryan Bouldin
John Ritter
Ellen Iverson she/her/hers
Laura Jackson Young
Bart
Rick Oches
Mitchell Awalt (he/him)
Christine Mooney
Jon Ericson
Gabe Courey
Otgo Erhemjamts
Melissa Lenczewski
Lindsay Meermans
Suzanne Dove
Nona
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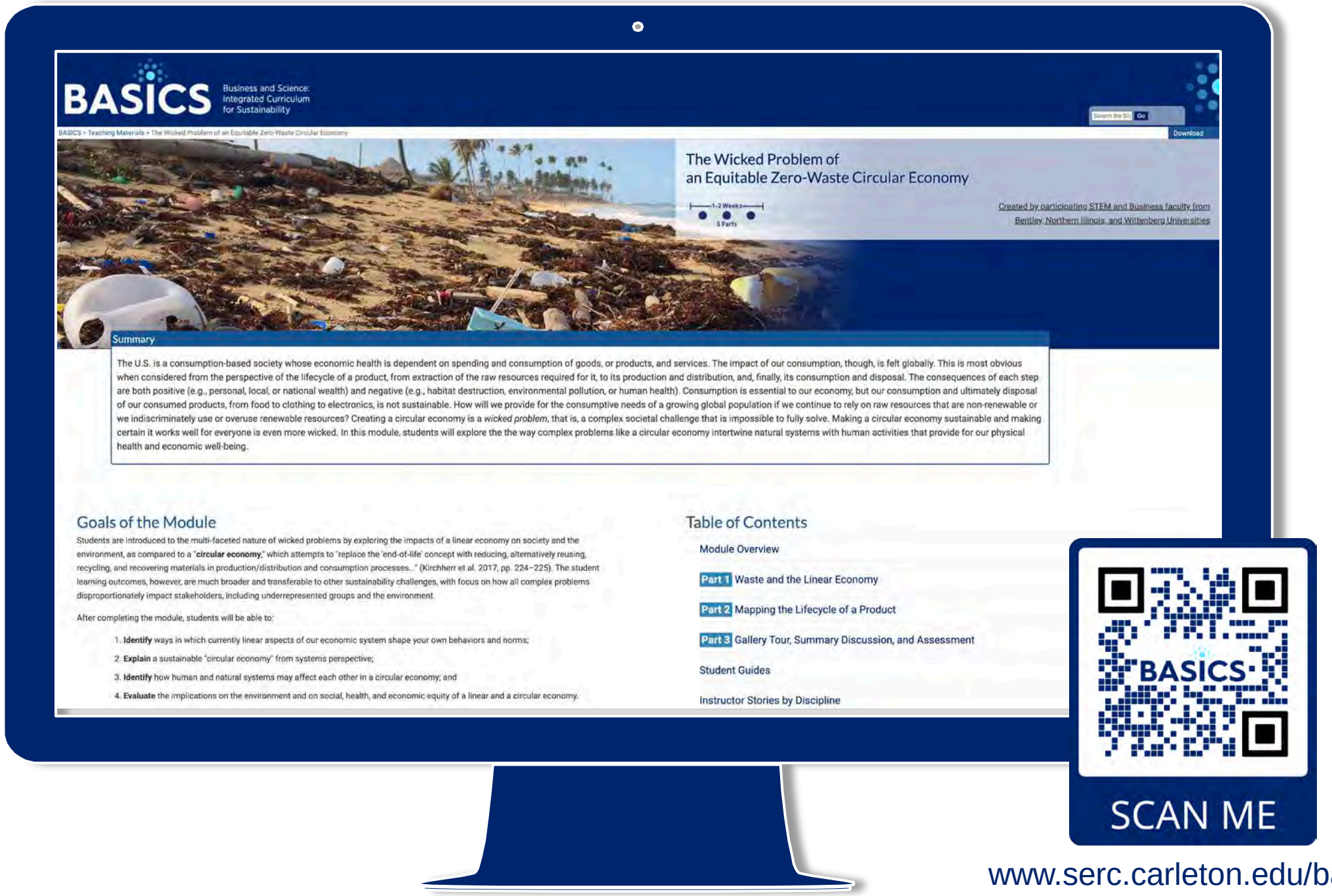
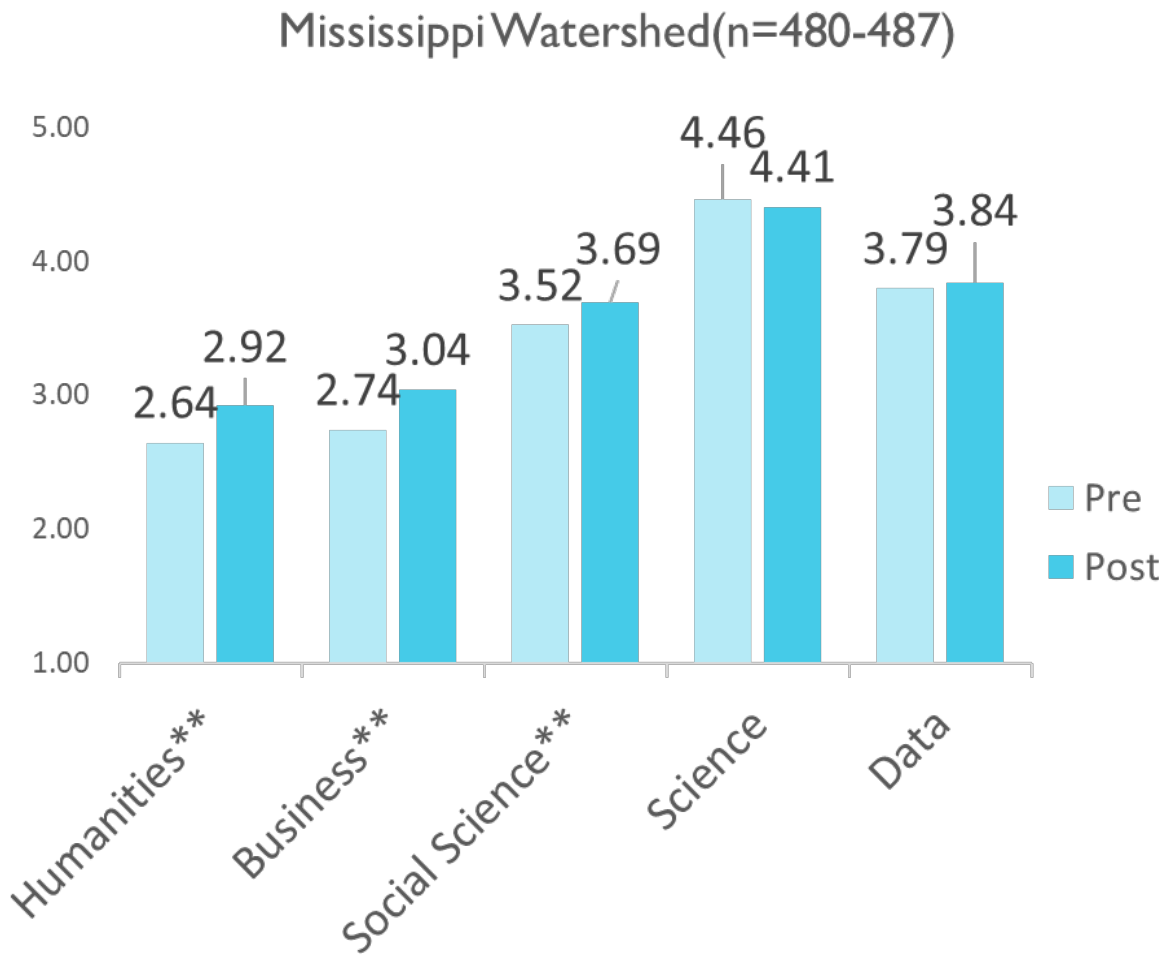
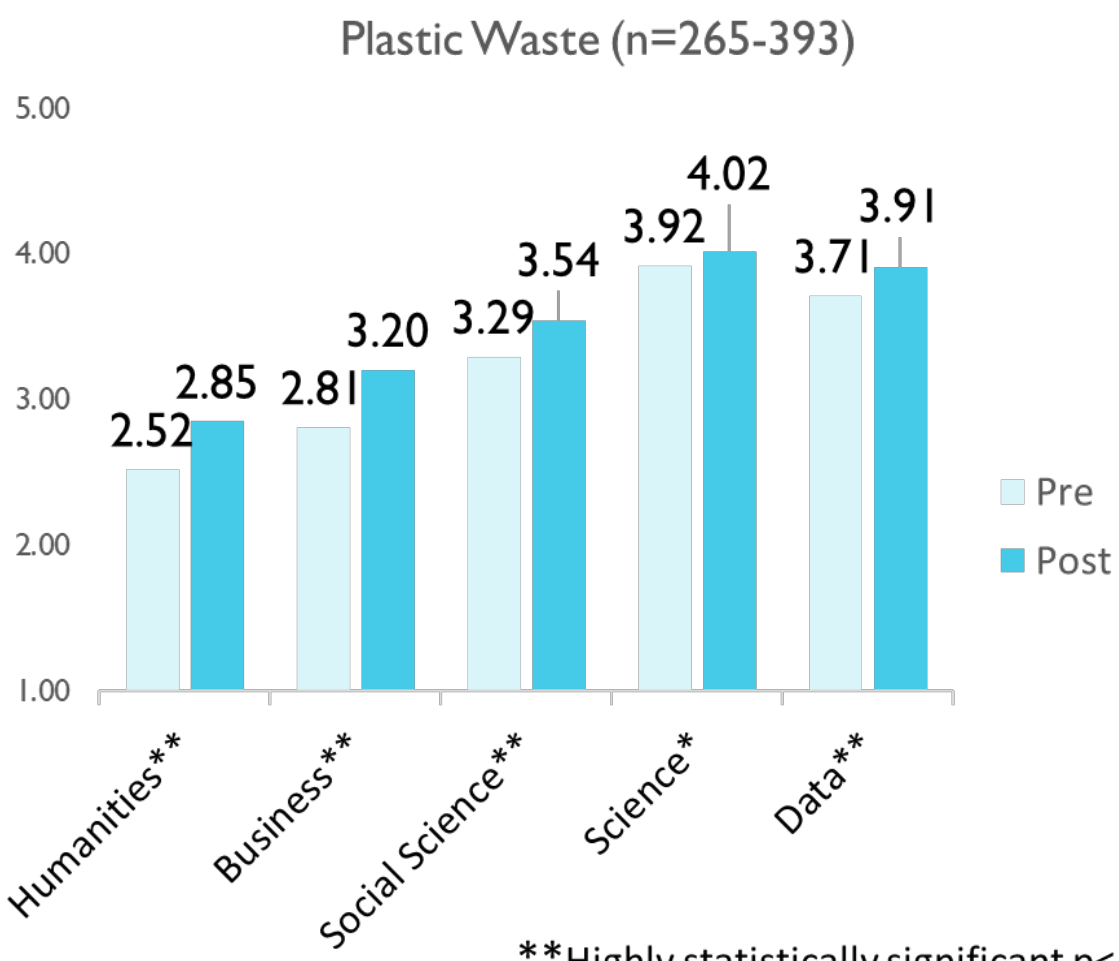
Stop Video
Security
Participants
23
Chat
1
Share Screen
Polling
Record
Breakout Rooms
Reactions



www.serc.carleton.edu/basics

Students completing the Circular Economy module in a course





1 to 5 scale: Not important, Slightly important, Moderately important, Important, Very important

**Highly statistically significant p<.001

*Statistically significant p=.01

Effect Size (Cohen's D)

Students completing the Mississippi Watershed Module

Discipline Category	Mississippi Watershed	Plastic Waste
Humanities	0.523 Moderate	0.440 Moderate
Business	0.851 Large	0.612 Moderate to Large
Social Science	0.658 Moderate to Large	0.488 Moderate
Science	0.108 Small	0.328 Small
Data	0.269 Small	0.213 Small

Students completing the Circular Economy Module

Discipline Category	Mississippi Watershed	Plastic Waste
Humanities	0.305 Small to Moderate	0.367 Small to Moderate
Business	0.313 Small to Moderate	0.411 Moderate
Social Science	0.088 Small	0.319 Small to Moderate
Science	0.044 Small	0.129 Small
Data	0.269 Small	0.192 Small

Impact on Faculty Change

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Imperatives, Challenges, Opportunities

- Transdisciplinarity imperatives: Students' futures and the social good.
- Limited research documents challenges and gains for faculty engaged in cross-disciplinary collaborations.
- Evaluation of BASICS allows exploration of rare faculty development of transdisciplinary curricula, and its teaching.
- Beyond data for continuous improvement, adding to the research base regarding faculty motivation and affordances and barriers for this work.

Lenhart, C., and Bouwma-Gearhart, J. (2022). Engaging students around the complex socioscientific issue of sustainability: Affordances and tensions of faculty working across disciplines to develop transdisciplinary curricula. *CBE—Life Sciences Education*, 21(2), ar21.

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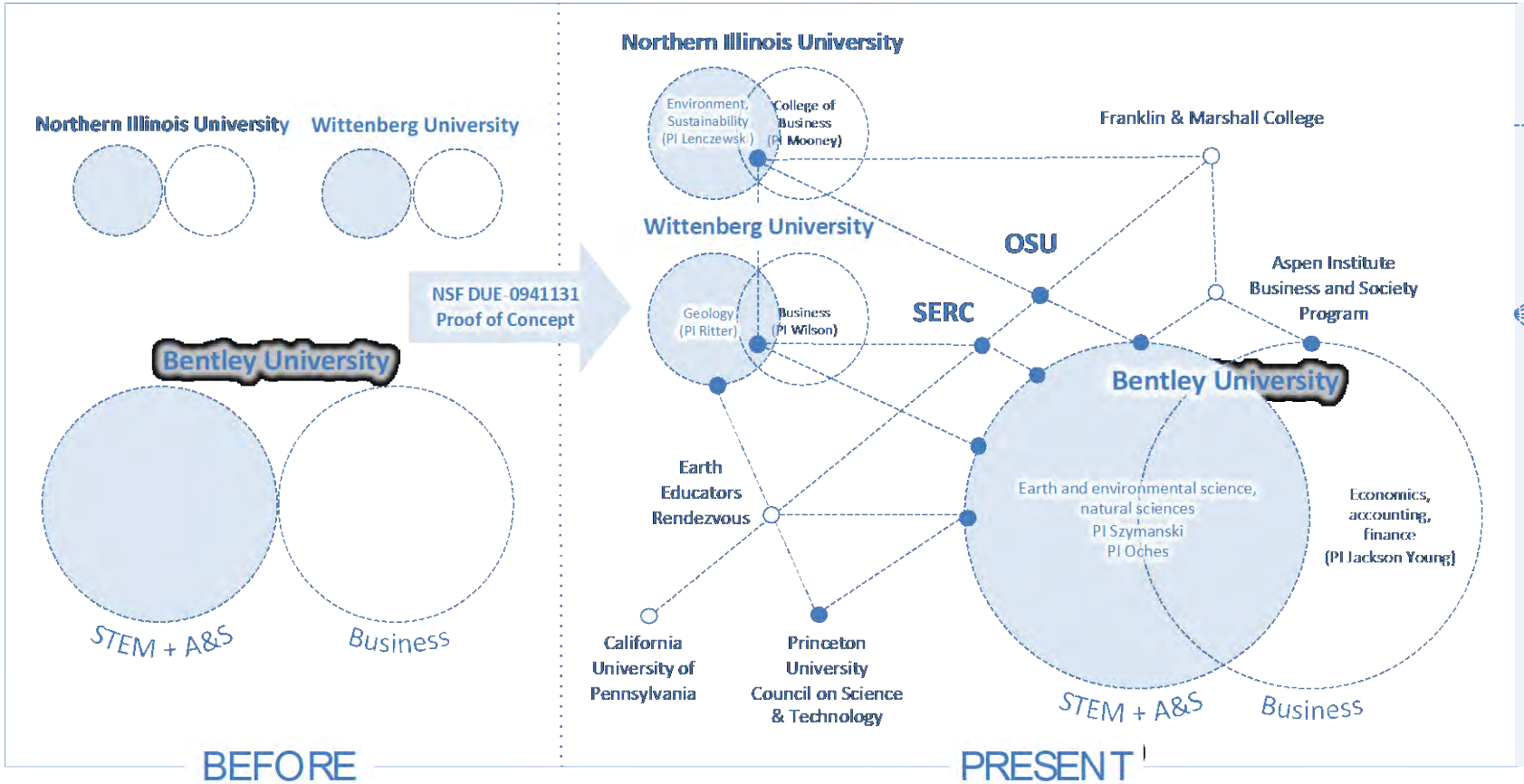

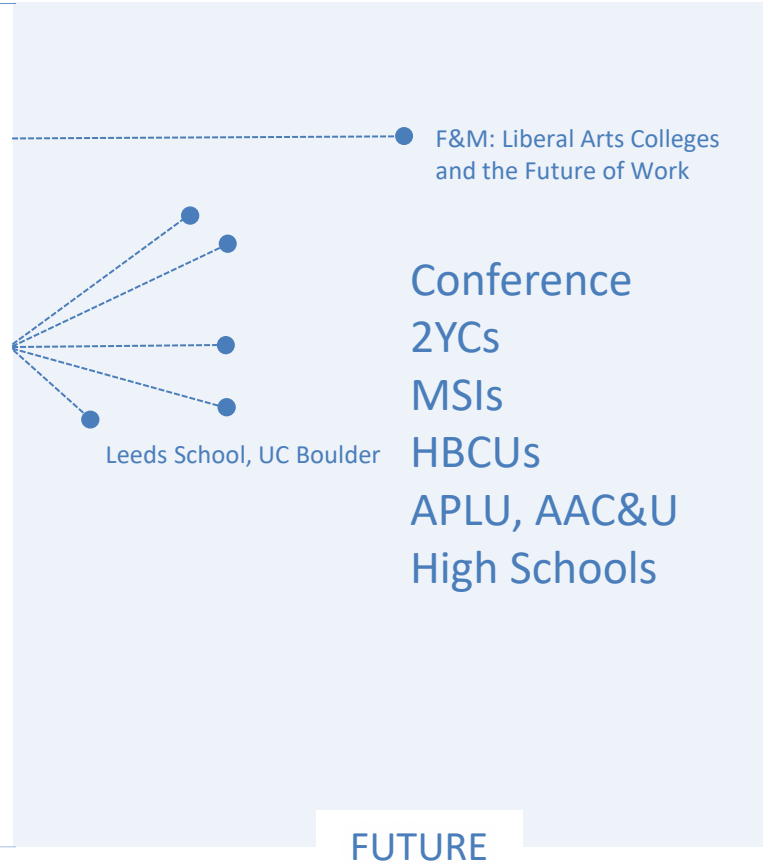

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Academy of Management
Accelerating Systemic Change Network
American Accounting Association
American Association for the Advancement of Science
American Association of Colleges and Universities
American Economic Association
Geological Society of America
Global Business School Network (Nov 2023)
Earth Educators' Rendezvous
Lilly Conferences (Jan 2024)

Highlights: Faculty Affordances

- Project leaders were essential alleviators of all tensions, effective facilitators, codevelopers and content/pedagogy experts
- Intensive and in-person work particularly meaningful
- Faculty internalized worth/increased commitment to TD teaching and learning, and topic of sustainability
- Later cohorts have benefitted from continuous project improvement in light of evaluation data
- Faculty seeking additional projects/coordination and funding for their continued work for TD curricula creation and implementation

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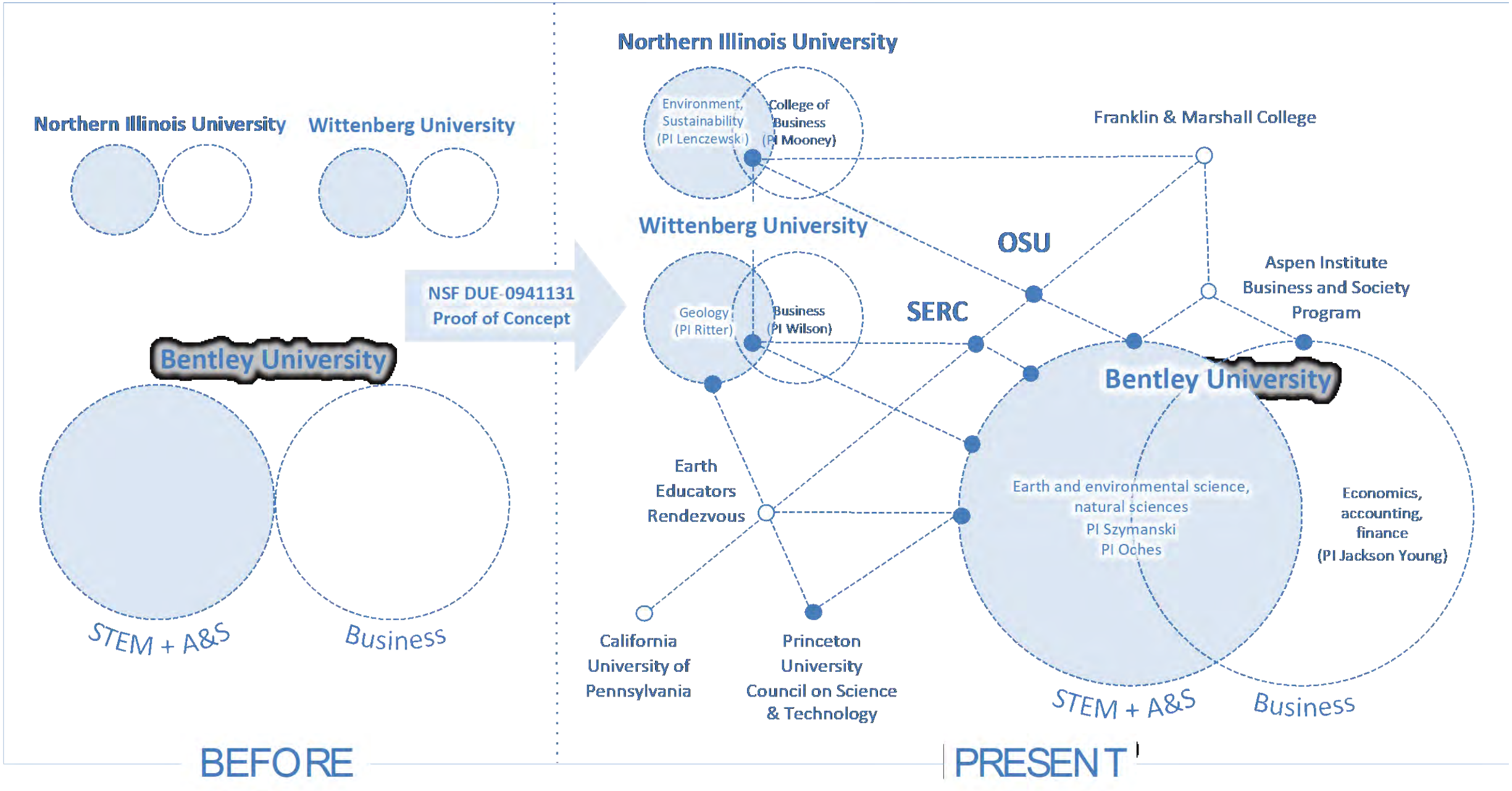
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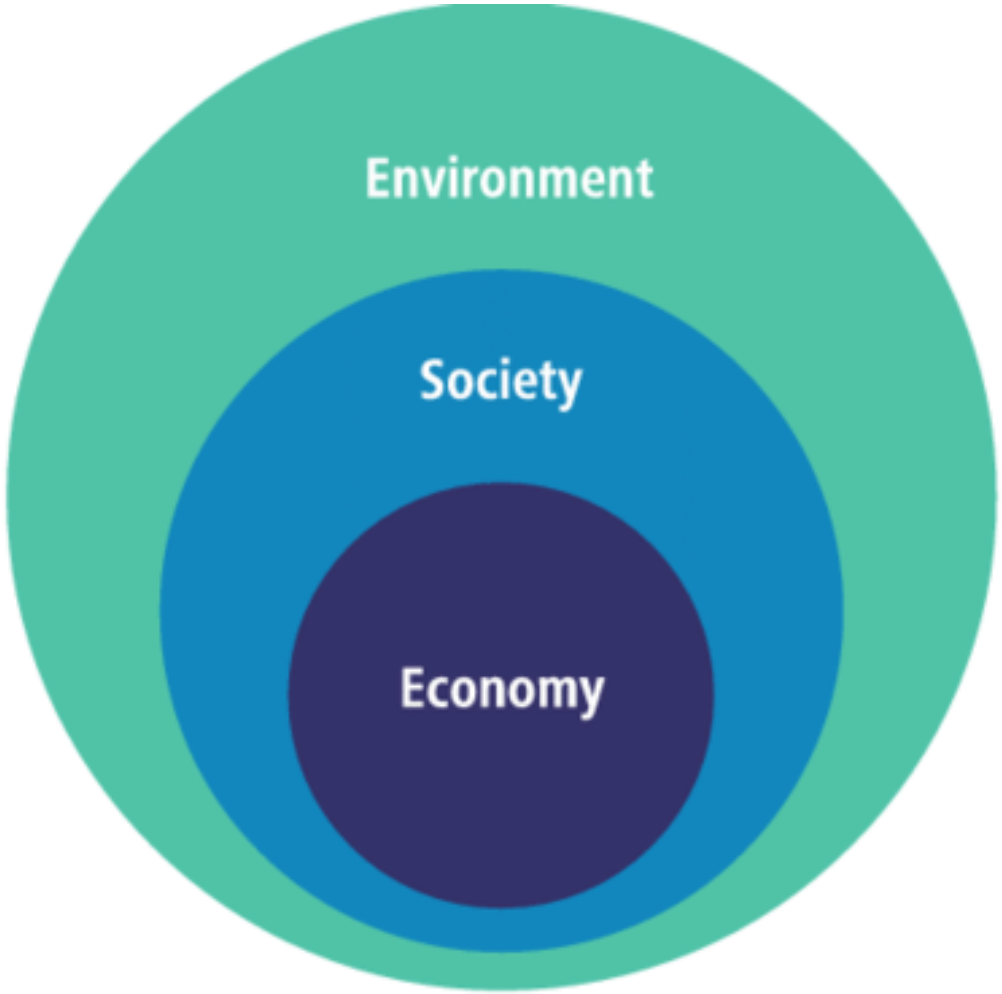
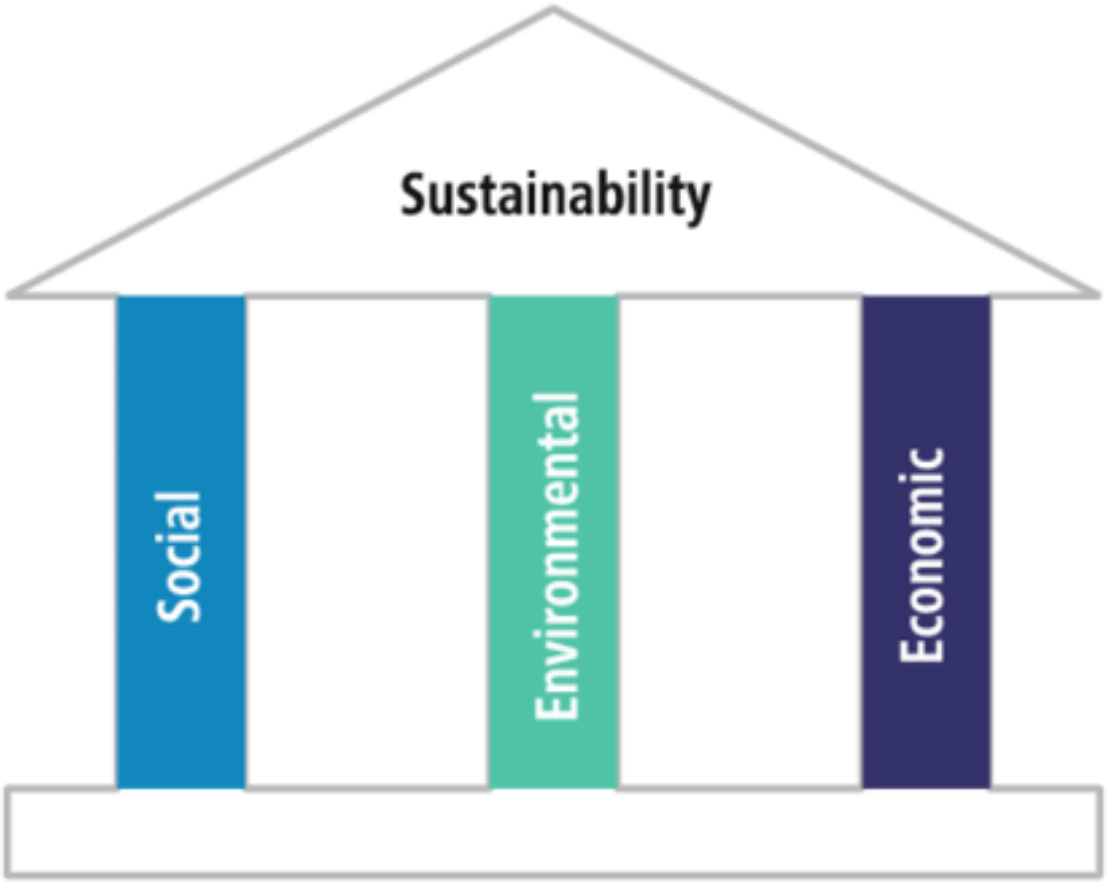
Wittenberg University
Bentley University
STEM + A&S
Business
BEFORE
NSF DUE-0941131
Proof of Concept
Northern Illinois University
Environment, Sustainability (PI Lenczewski)
College of Business (PI Mooney)
Wittenberg University
Geology (PI Ritter)
Business (PI Wilson)
Franklin & Marshall College
OSU
SERC
Aspen Institute Business and Society Program
Bentley University
Earth and environmental science, natural sciences
PI Szymanski
PI Oches
Economics, accounting, finance
(PI Jackson Young)
Earth Educators Rendezvous
California University of Pennsylvania
Princeton University Council on Science & Technology
STEM + A&S
Business
PRESENT





Maja Göpel. (2016). Why the Mainstream Economic Paradigm Cannot Inform Sustainability Transformations. *The Great Mindshift* (pp53-117).

The Wicked Problem of an Equitable Zero-Waste Circular Economy

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BASICS Student Learning Outcomes

Identify ways in which currently linear aspects of our economic system shape your own behaviors and norms.

Explain a sustainable “circular economy" from a systems perspective.

Identify how human and natural systems may affect each other in a circular economy.

Evaluate the implications on the environment and on social, health and economic equity of a linear and a circular economy.