ASSESSING STUDENT LEARNING ABOUT SUSTAINABILITY AND WICKED PROBLEMS THROUGH TRANSDISCIPLINARY CURRICULUM MODULES

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Introduction

In order to become citizens and leaders capable of addressing wicked problems such as sustainability, students need education that transcends disciplinary boundaries and allows them to engage in critical thinking around complex problems. To this end, the Business and Science: Integrated Curriculum for Sustainability (BASICS) project seeks to produce and test transdisciplinary curricular modules that can be used in geoscience, other STEM fields, and business courses to help students develop the skills and knowledge to tackle wicked problems

Transdisciplinary Curriculum Modules

A multidisciplinary cohort of faculty from three institutions created a "common exercise" that introduces students to the transdisciplinary nature of sustainability. The exercise focuses on the multi-faceted nature of nitrogen pollution in the Mississippi River watershed and was piloted in a variety of disciplines and courses over the 2020-21 academic year. Surveys were administered before and after the implementation of the exercise that collected student attitudes and abilities to address complex problems.

A second module focused on exploring the impacts of linear and circular economies on society and the environment is currently being piloted.

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Student Surveys

Pre- and post-module surveys to students served to characterize enrollment by class year; measure changes in pre-post related to attitudes related to sustainability, changes in students' perceived knowledge related to systems thinking, and changes in the influences of disciplinary fields to solving a wicked problem; and measure post-self-reported learning gains related to interdisciplinary approaches.

Table 1.The number of enrolled students and respondents and the overall, pre-survey, post-survey, and paired response rates.

	Enrolled Students	Respondents	Overall Response Rate	Pre-Survey Response Rate	Post-Survey Response Rate	Paired Response Rate
Total	488	349	72%	67%	52%	49%
Minimum (by course)	16	5	31%	25%	27%	25%
Maximum (by course)	68	54	96%	91%	91%	86%

Figure 1. The percentages of students for each class year (n=321).

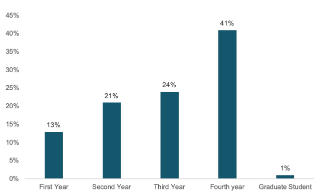
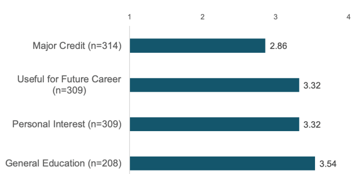


Figure 2. The average ratings for each reason for enrollment in the course.



Using transdisciplinary teaching materials that allow students to explore complex problems increases students' understanding of drawing skills and knowledge from multiple disciplines to address wicked problems related to sustainability.

Importance of Disciplines to Address a Wicked Problem

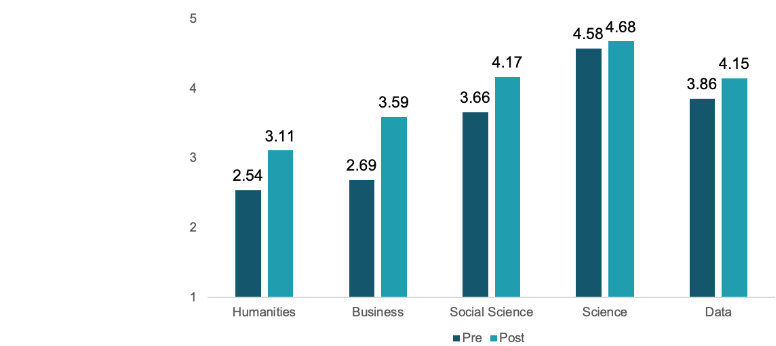


Figure 3. The pre- and post-survey mean ratings for importance of each discipline category to solving the wicked problem. (n=232)

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Survey Data

Importance of Disciplines to the Wicked Problem

Students were presented with a wicked problem and asked to identify the importance of different disciplines on which to draw expertise to address the challenge. The importance of each deiscipline was rated on a five-point scale (1=not important to 5=very important). From pre- to post-surveys, the mean ratings increased for each discipline (Figure 3, left). To better understand the change in means, we took into consideration the effect size (d-value), which is a measure of the change in average rating from pre- to post-survey (Table 3).

Table 3. The effect size (d-value) range and their interpretation for each discipline category.

Discipline Category	Range of d-value	Interpretation of d-value
Humanities	0.500-0.510	Moderate
Business	0.861-0.951	Large
Social Science	0.679-0.804	Moderate to Large
Science	0.221-0.224	Small
Data	0.289-0.300	Small

Reported Learning Gains

Students were asked to answer a subset of questions from the Research on the Integrated Science Curriculum (RISC) Survey[1]. The RISC Survey has students rate their learning gains for a series of statements on a 5-point scale (1=none or very small gain to 5=very large gain). Average ratings from students were compared published data of all students who completed the RISC survey nationally in 2016[2] (n=3506). Students reported a range of gains from 3.17 (moderate gain) to 4.02 (large gain)(Table 4). Comparison of gains to published data from Cookmeyer et al. (2017) shows that BASICS student gains exceed those of the comparison group in most categories.

Table 4. Student self-reported gains in post-survey in response to the prompt, "Please rate how much learning you gained from each element you experienced to date in this course:"

Statement	BASICS Mean Rating	RISC Sample (n=3506)
Learning that disciplines may approach problems in different and sometimes conflicting ways (n=251)	4.02	3.8
Attempting a complete understanding of a complex problem (n=249)	3.94	3.65
Working on a problem that requires integrating ideas from two or more disciplines (n=249)	3.93	3.55
Studying problems with multiple causes that operate simultaneously and Interactively (n=249)	3.91	3.5
Learning to ask "big questions" that implicate more than one discipline in a solution (n=249)	3.88	3.6
Studying an interdisciplinary problem (n=250)	3.83	3.5
Working on problems that have no clear solution (n=252)	3.78	3.4
Engaging in class discussion (n=250)	3.74	3.5
Learning to find similarities and differences between disciplines or fields of study (n=248)	3.74	3.7
Becoming responsible for part of a project (n=251)	3.71	3.5
Receiving assigned coursework from more than one discipline or area of study (n=250)	3.70	3.4

Statement	BASICS Mean Rating	RISC Sample (n=3506)
Using instruments or materials borrowed from another discipline or field of study (n=250)	3.68	3.5
Connecting your personal experience to course problem or problems (n=251)	3.66	3.35
Judging the relative contribution of disciplines to the solution of a problem (n=251)	3.62	3.4
Calling upon personal values to motivate the study of the problem or problems (n=250)	3.62	3.85
Working in small groups or teams (n=250)	3.59	3.85
Working with students who major (or intend to major) in other disciplines as fields of study (n=251)	3.59	3.5
Learning about two (or more) disciplines so that new insights emerge from considering them together (n=251)	3.58	3.48
Presenting intellectual work orally (n=247)	3.57	3.48
Reading primary literature from multiple disciplines or fields of study (n=249)	3.55	3.5
Listening to lectures (n=251)	3.35	3.51
Learning to translate the specialized language of a discipline into the language of other disciplines (n=251)	3.28	3.1
Critiquing the work of other students (n=248)	3.17	3.2

[1] Lopatto, D. (2018). RISC Survey. Grinnell College. https://www.grinnell.edu/academics/centers-programs/ctla/assessment/risc
[2] Cookmeyer, D. L., Winesett, E. S., Kokona, B., Huff, A. R., Aliev, S., Bloch, N. B., ... & Charkoudian, L. K. (2017). Uncovering protein–protein interactions through a team-based undergraduate biochemistry course. PLoS biology, 15(11), e2003145.

Key Findings

- Students indicated an increased perception of importance of multiple discipline to solving the wicked problem.
- Students reported the highest gains in the following RISC items:
  - Learning that disciplines may approach problems in different and sometimes conflicting ways
  - Attempting a complete understanding of a complex problem
  - Working on a problem that requires integrating ideas from two or more disciplines

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