

## Introduction and Rationale

At the Jasper Department of Chemical Engineering, we promote sustainability. Part of this vision is understanding that true sustainability, from economic and environmental perspectives, can only be achieved when humans practice its principles.

- The main driver for sustainability training and education in Chemical Engineering is the evolution of the industry. Future chemical engineers will need to focus on developing the circular economy with green chemistry, water conservation and carbon capture, all vital parts of sustainability practices.
- Students in our programs graduate and help grow our network across East Texas. Through a network of chemical engineers in East Texas, we have managed to develop a department culture focused on community impact, outreach and leadership, promoting engineering careers tied to sustainable socio-environmental practices.

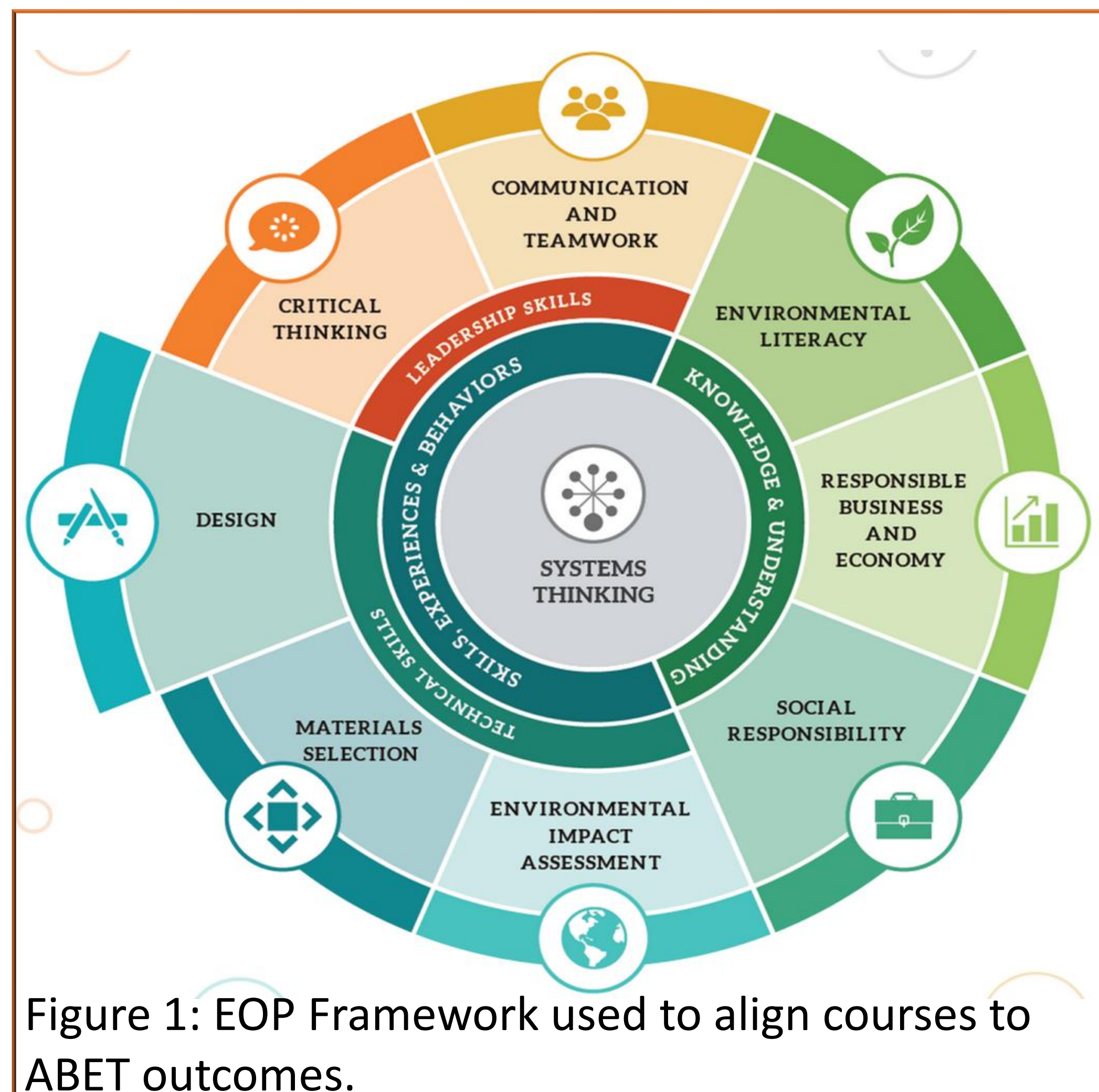


Figure 1: EOP Framework used to align courses to ABET outcomes.

## Mini-Grant Goal

The research goal with the EOP Framework is a year-to-year curricular integration of sustainability principles, i.e., critical thinking and teamwork (years 1 and 2), design and materials selection (year 3), environmental impact and business literacy (year 4), directly aligned with ABET outcomes. The EOP framework was piloted in the Chemical Engineering curriculum last Fall and will continue in the upcoming years. Preliminary findings are presented here.

## Sample Project Pages

### MATERIALS SELECTION

Criterion	PU Foam	EPS	Molded Pulp
Shock Absorption	Excellent	High	Moderate
Tensile Strength	Low	Very Low	Moderate-High
Recyclability	Limited	Limited	High
Biodegradability	No	No	Yes
Cost	High	Low	Moderate
Environmental Impact	Moderate-High	High	Low

### CRITICAL THINKING

To determine the energy efficiency and its cost,

$$E_{day} = P(W) \cdot \frac{kWh}{1000W} \cdot \frac{24hr}{day}$$

Using the energy consumed per day can then be factored with avg cost per kWh,

$$C_{day} = E_{day} \cdot 0.14$$

24hr Run Time Data Analysis	LED	OLED	ηOLED
Input Power (W)	180-260	150-250	150-200
Energy Consumption (kWh/day)	4.32-6.24	3.60-6.00	3.6-4.80
Daily Cost (USD/day) (\$0.14/kWh)	0.60-0.87	0.50-0.84	0.50-0.67

### IMPACT ASSESSMENT

Figure 2 – Completed LEED checklist.

### BUSINESS AND ECONOMY

Risk Area	Weight	Classic Process	Eco-Enthusiast	Quality Driven
Technical	5	9.17	16.67	17.50
Economic	2	5	4	6
Commercial	4	10.67	10.67	13.33
Organizational	1	2	2.5	2
Political	5	17	8	14

Table 2.7 – Amine Emissions Weighted Averages

Summing the total weighted scores gives the following results for the Amine Emissions group.

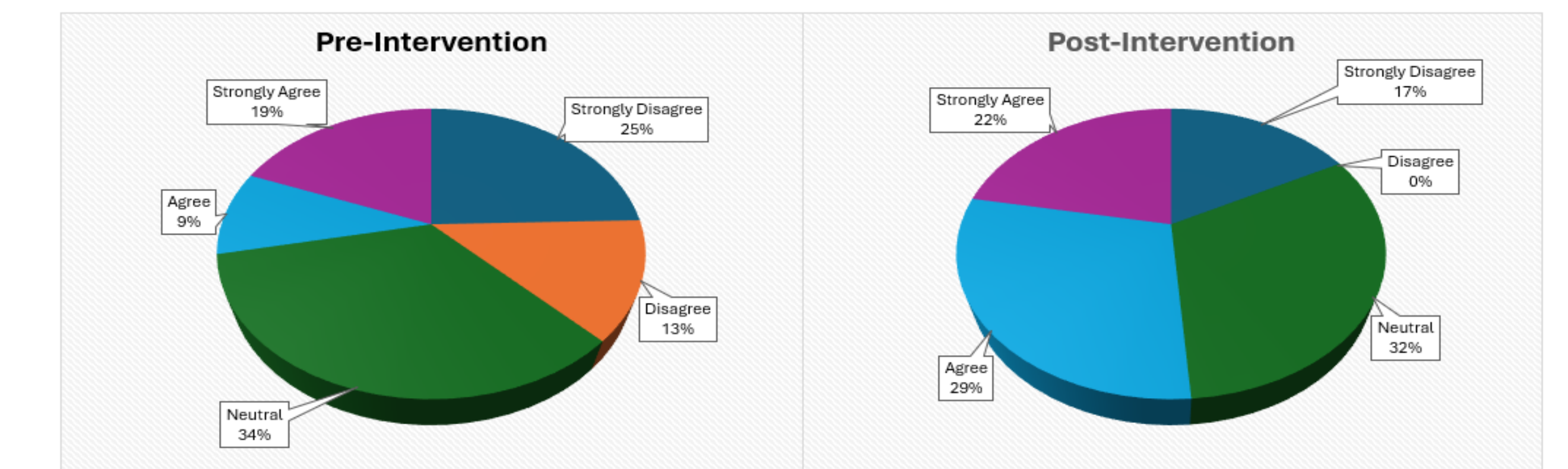
	Classic Process	Eco-Enthusiast	Quality Driven
Final Weighted Score	186	185	221

Table 2.8 – Amine Emissions Final Weighted Scores

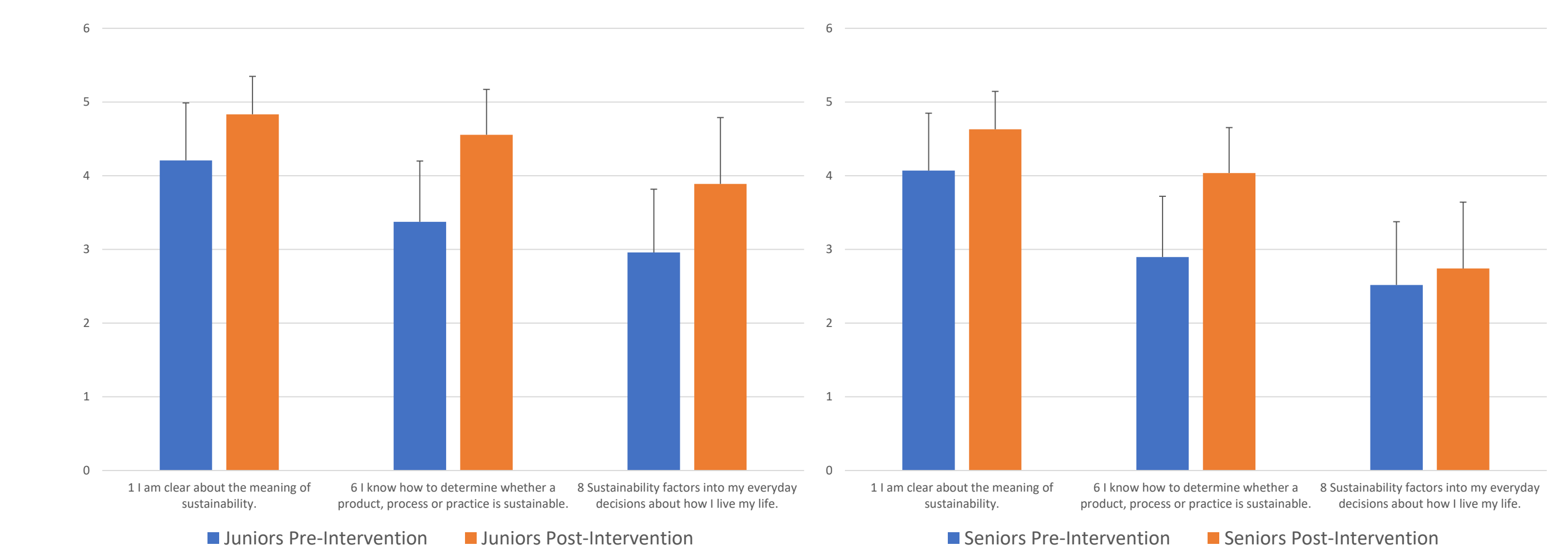
## Results and Impact

### One sobering reality

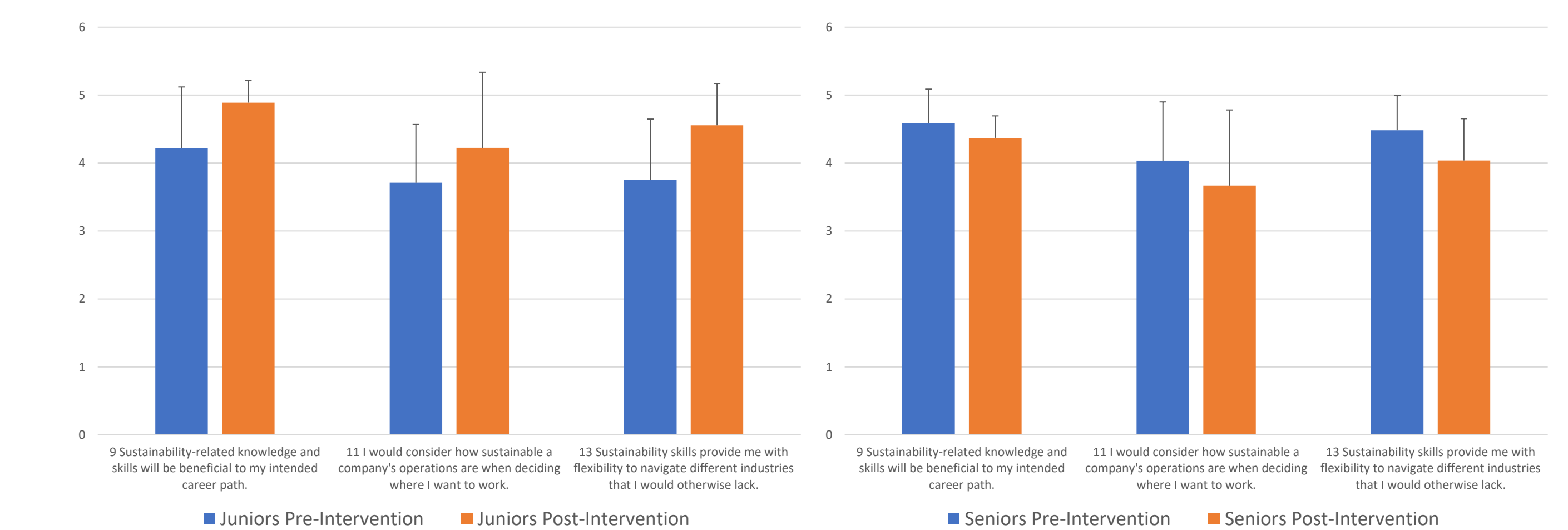
I believe that my lifestyle has an impact on climate change.



### Some attitudes improved



### While other improvements were only seen in distinct populations



## Reflections

With a strong emphasis on energy and petrochemical industries, reflections broadly captured how the status quo is non-sustainable. As trained professionals, innovation and mindset change will need to lead the next century for sustainable design and development.

## Impact

With the EOP framework in place, we aim to make our region a pioneer in sustainable energy exploration, given proper engineering training, support from local industries and community mindset. Since our team is our entire department we anticipate continuing the program to strengthen the core curriculum. Our current and future industrial partnerships will focus on sustainable facility design and sustainable processing, particularly focusing on reduction of emissions.

## Methodology – Course Assignment

Table 1: The specific courses offered along with their instructors were matched with EOP core principles and divided up between Fall and Spring semesters. The colors indicate the student populations reached: Seniors, Juniors and Sophomores.

Course	Instructor	Sustainability Principle
CHEN 3302 – Thermo II	Liu	Critical thinking
CHEN 3310 – Materials	Cao	Materials selection
CHEN 4170 – Design I	Resende	Business and economy
CHEN 4310 – Separations	Lacerda	Environmental literacy
CHEN 4330 – Process Control	Lacerda	Environmental impact
<b>Spring Course</b>	<b>Instructor</b>	<b>Sustainability Principle</b>
CHEN 3340 – Heat Transfer	Cao	Communication and teamwork
CHEN 3301 – Thermo I	Liu	Social responsibility
CHEN 3360 – Reactors	Wang	Design
CHEN 4371 – Design II	Resende	Systems thinking

## Methodology – Reflections and Surveys

Table 2: Specific questions asked to students before and after sustainability lectures and projects. Open-ended reflections and sample projects are also introduced in the sections that follow.

Agreement with the following (1 = strongly disagree; 5 = strongly agree)

1	2	3	4	5	Statement
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I am clear about the meaning of sustainability.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I believe that environmental contamination is a threat to sustainability.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I believe that water and energy demands pose threats to sustainability.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I believe that my lifestyle has an impact on climate change.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I often think about how to make certain products or processes more sustainable.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I know how to determine whether a product, process or practice is sustainable.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	A waste-free lifestyle/economy is necessary for sustainable development.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sustainability factors into my everyday decisions about how I live my life.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sustainability-related knowledge and skills will be beneficial to my intended career path.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I am interested in learning more about how to apply different sustainability concepts into my career.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I would consider how sustainable a company's operations are when deciding where I want to work.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I believe potential employers are interested in hiring students with sustainability-related knowledge and skills.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sustainability skills provide me with flexibility to navigate different industries that I would otherwise lack.