Incorporating Practical, Socially Aware, Sustainable Engineering Solutions in Engineering Coursework

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Introduction

❖ This project involved developing and incorporating targeted EOP concepts, such as sustainability, critical thinking, systems thinking, teams and communication, to multiple engineering courses:
  ➢ ENGR 4230 Project Management (senior)
  ➢ ENGR 4370 Capstone Projects (senior)
  ➢ ENGR 4390 Special Topics: AI in Engineering and Science Applications (to be offered for the first time in fall 2023) (junior, senior)
  ➢ EEEN 3318 Microprocessors and Microcontrollers (fall 2023)

❖ In Project Management and Capstone Projects courses, environmental and social sustainability was incorporated when considering project design and expected impacts.

❖ In ENGR 4390 Special Topics course, new course materials were developed including assignments, hands-on programming exercises, class projects that promoted critical thinking about sustainability of engineering solutions, global impacts, and importance of being inclusive in engineering design.

Procedure

❖ Use EOP Framework as a guide when designing coursework as well as student assignments that will expect students to
  ➢ Consider sustainability in engineering, engineering design, engineering solutions
  ➢ Incorporate critical thinking when analyzing their own and others work
  ➢ Work in teams towards a common goal that addresses environmental and social sustainability in engineering solutions pertinent to each class.
  ➢ Communicate effectively

❖ Develop faculty mentor training materials for sustainability in design concepts, systems engineering/thinking concepts

❖ Implement exercises for students to practice the EOP concepts in their courses and projects.

Progress

❖ Sustainability concepts - environmental and social sustainability DURING DESIGN
  ENGR 4240 Project Management
  ENGR 4370 Capstone Projects
  EEEN 3418 Microprocessors and Microcontrollers
❖ Critical Thinking – sustainability of engineering solutions, global impacts and being inclusive in engineering design
  ENGR 4240, ENGR 4370,
  ENGR 4390 Special Topics: AI in Engineering and Science Applications (new course))
❖ Diversity of Thought, Inclusion of Different Perspectives
❖ Impacts Assessment
❖ Faculty mentor guidelines on sustainability in and during design

Also added:
❖ Systems Thinking
  ➢ "Whole System Mapping"
  ➢ "Measuring Sustainability"
  ➢ Systems Engineering (systems thinking) in EEEN 3418 Microprocessors and Microcontrollers, and (to be added in ENGR 4370 Capstone Projects in 2024)

Sustainability diagram of the sinkhole formation tank

Whole System Mapping

Measuring Sustainability: Life Cycle Assessment (LCA)

Plan for Scaling Up

In the spirit of sustainability, the following continuation of implementation and assessment of impact of EOP concepts (sustainability, critical thinking, Diversity of Thought, Inclusion of Different Perspectives) are planned in 2024:

Scaling up	Topic/Timeline	EOP Concepts
ENGR 4370/ ENTC 4350	Capstone Projects / Spring 2024	A., C., D., E., F
ENGR 4390 Special Topics	AI in Engineering and Science Applications / Fall 2024	A., B., D.
MEEN 4345 / EEEN 4345	Sensors and Systems / Summer 2024	B., F
ENGR 4240/ ENTC 4415	Project Management (second iteration) / Fall 2024	A., B., C., D., E., F.
EEEN 3418	Microprocessors and Microcontrollers	A., C., F.
Faculty	Mentor Training/ Spring-Fall 2024	A., C.

EOP Concepts
A. Sustainability in Design
B. Critical Thinking
C. Systems Thinking
D. Diversity of Thought, Inclusion of Different Perspectives
E. Social Responsibility
F. Communication and Teamwork

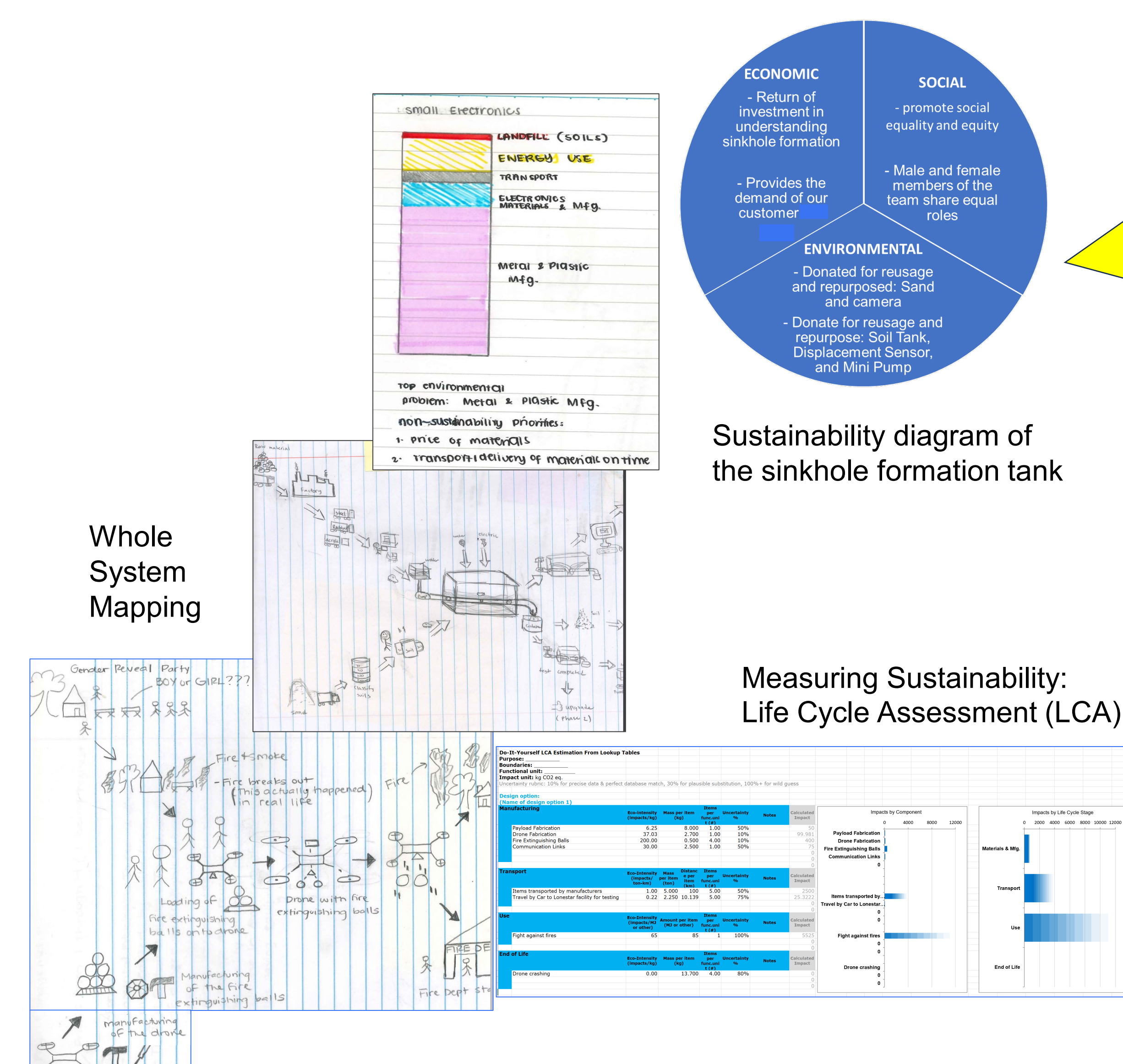| Rubric for Assessment of Effective Communication			
Dimension	Proficient	Developing	Beginning
Presentation	Maintains good eye contact throughout / Uses expressive and appropriate body language / Does not fumble with computer or projector	Stands up straight and establishes good eye contact with everyone in the room during the presentation	Slouches and/or does not look at people during the presentation
Preparedness	Student is completely prepared and has obviously rehearsed	Student seems pretty prepared but might have needed a couple more rehearsals	Student does not seem prepared to present
Content	Provides handouts that are clear and show key issues / Cites at least three sources related to the target audience / Presents concise PowerPoint slides / Provides clear reasons why information is relevant	Shows a good understanding of the topic / Part of information is presented without rationale / Cites two sources related to the target audience	Does not seem to understand the topic very well / No rationale is provided regarding why information presented is relevant / Does not cite sources related to the target audience

Evaluation

What Worked
❖ EoP Framework
❖ EoP Leadership Team
❖ EOP Mentors as resources/guides
❖ Teamwork: Project Team
❖ Cohort Meetings
❖ Flexibility (time to deliver)
❖ Hands-on learning activities

Impact

❖ **51** undergraduate STEM students were impacted in 4 courses (fall 2023)
  ➢ **49** Engineering (Electrical, Mechanical, Civil, Industrial)
  ➢ **2** Mechanical Engineering Technology
❖ **2** faculty were engaged in the activities (fall 2023)
❖ **3** additional courses in spring 2024), **1** course in summer 2024, and **3** courses in fall 2024 will continue to implement the targeted EOP concepts.
❖ Senior capstone design project mentors will be provided with Sustainable Design training materials for mentoring the students in their design projects.

References

➢ Engineering for One Planet Resources: Integrating sustainability into engineering education to protect and improve our planet and lives (https://engineeringforoneplanet.org/)
➢ EOP Framework: Essential Sustainability-focused Learning Outcomes for Engineering Education (2022) (https://engineeringforoneplanet.org/wp-content/uploads/EOP_Framework_2023.pdf)
➢ Whole System Mapping, Venturewell (https://venturewell.org/tools_for_design/introduction/)
➢ Blanchard, B., & Fabrycky, W. Systems Engineering and Analysis, Prentice Hall International Series in Industrial & Systems Engineering, 5th Edition, 2023.
➢ B. Purvis, Y. Mao, and D. Robinson, "Three pillars of sustainability: in search of conceptual origins," Sustain Sci, vol. 14, no. 3, pp. 681–695, May 2019, doi: 10.1007/s11625-018-0627-5.

Acknowledgment