Human behavior outcomes of plastic and bioplastic disposal

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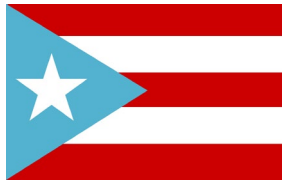
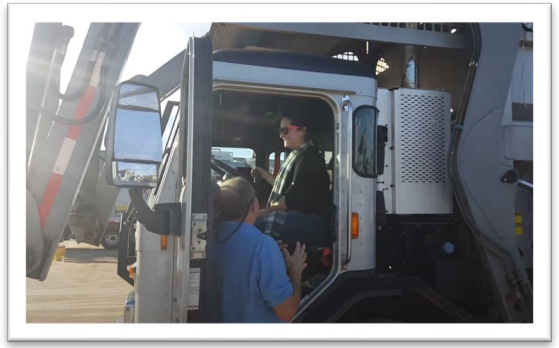


2017

POLYTECHNIC UNIVERSITY PUERTO RICO



2019

NSF Graduate Research Fellowship Program

2019

College of Engineering
UNIVERSITY OF WISCONSIN-MADISON

2021

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Thesis Defense
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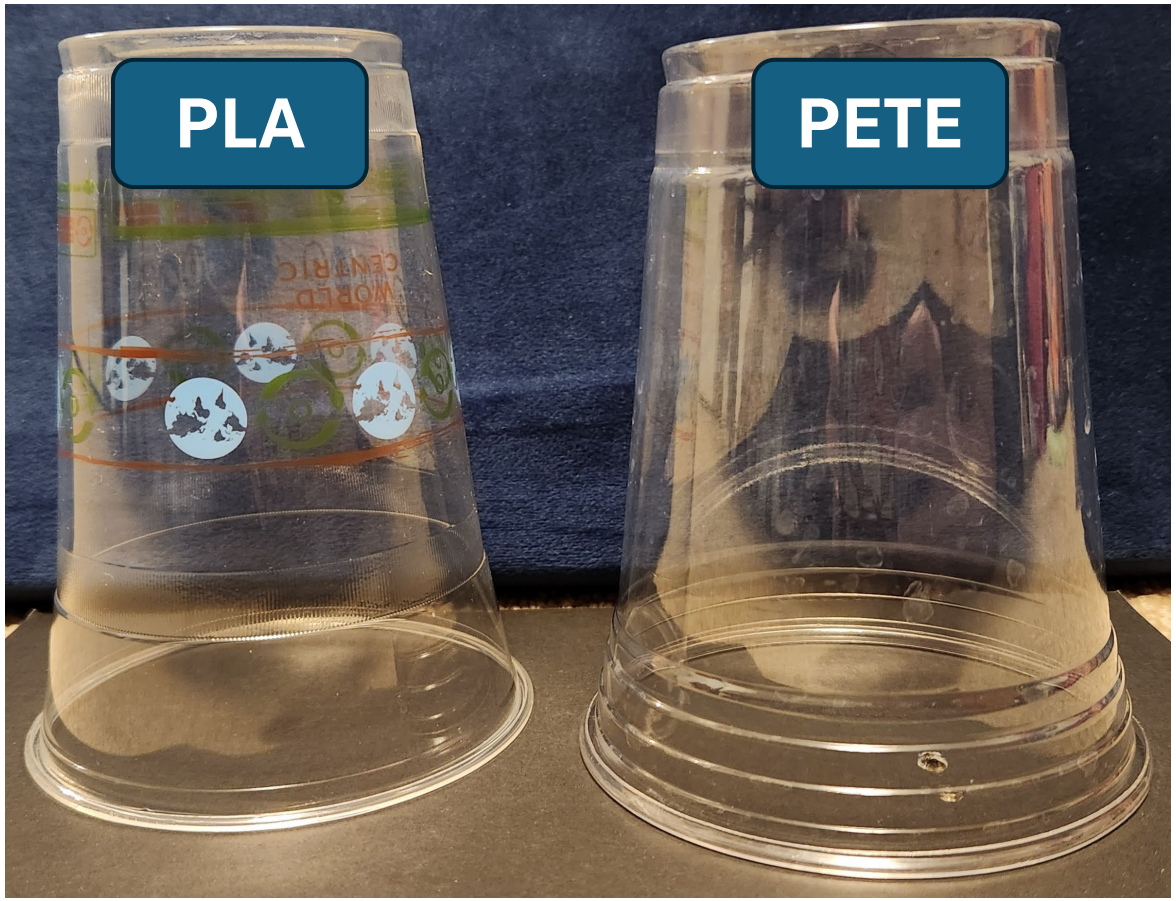
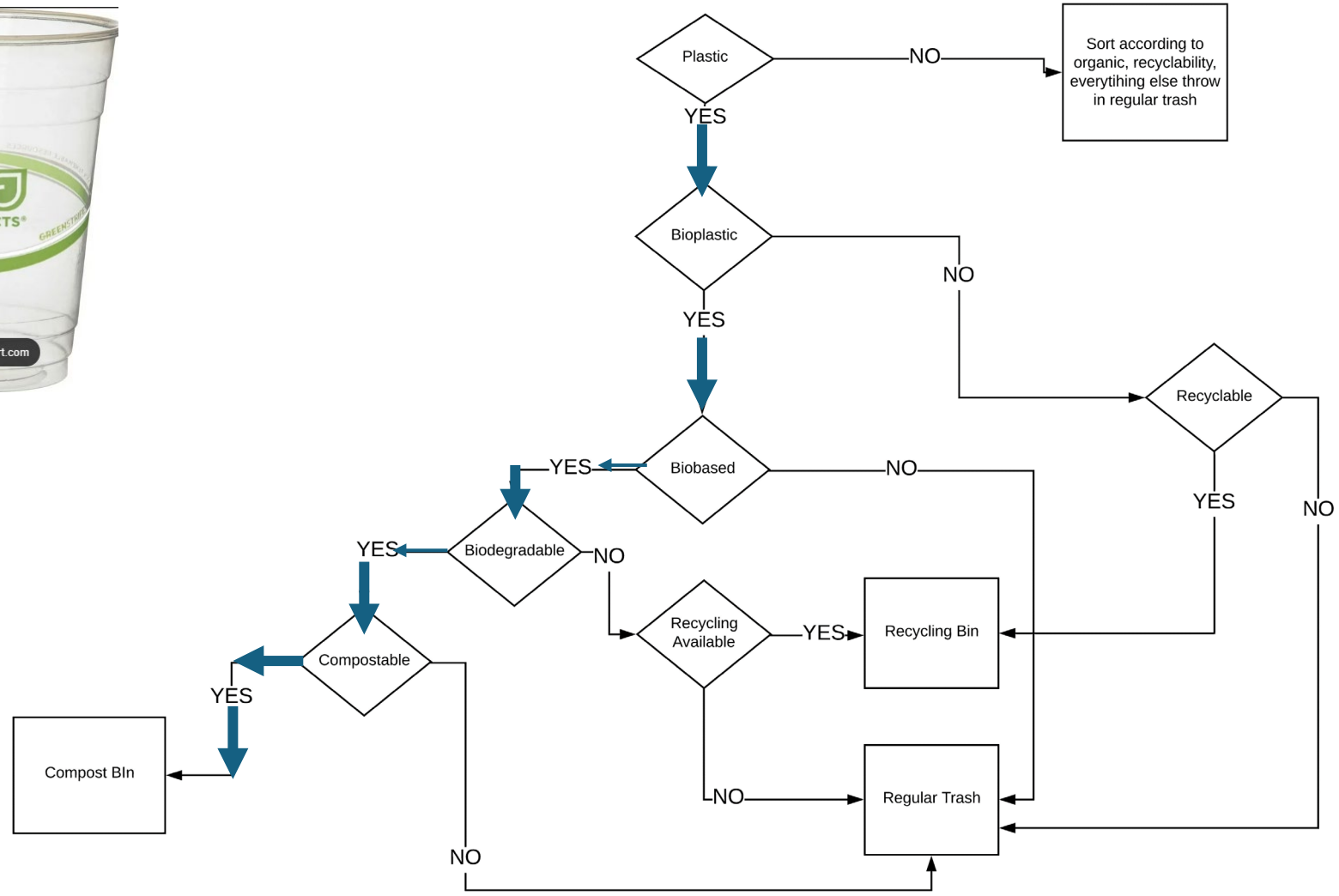
Decision making is tough,

making disposal choices as a consumer is difficult too.

Several factors make it even more complicated

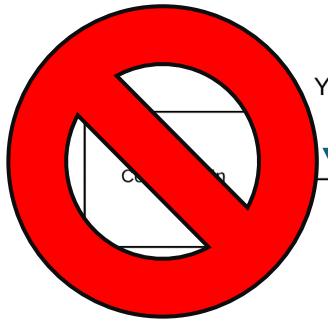

PLA
PETE

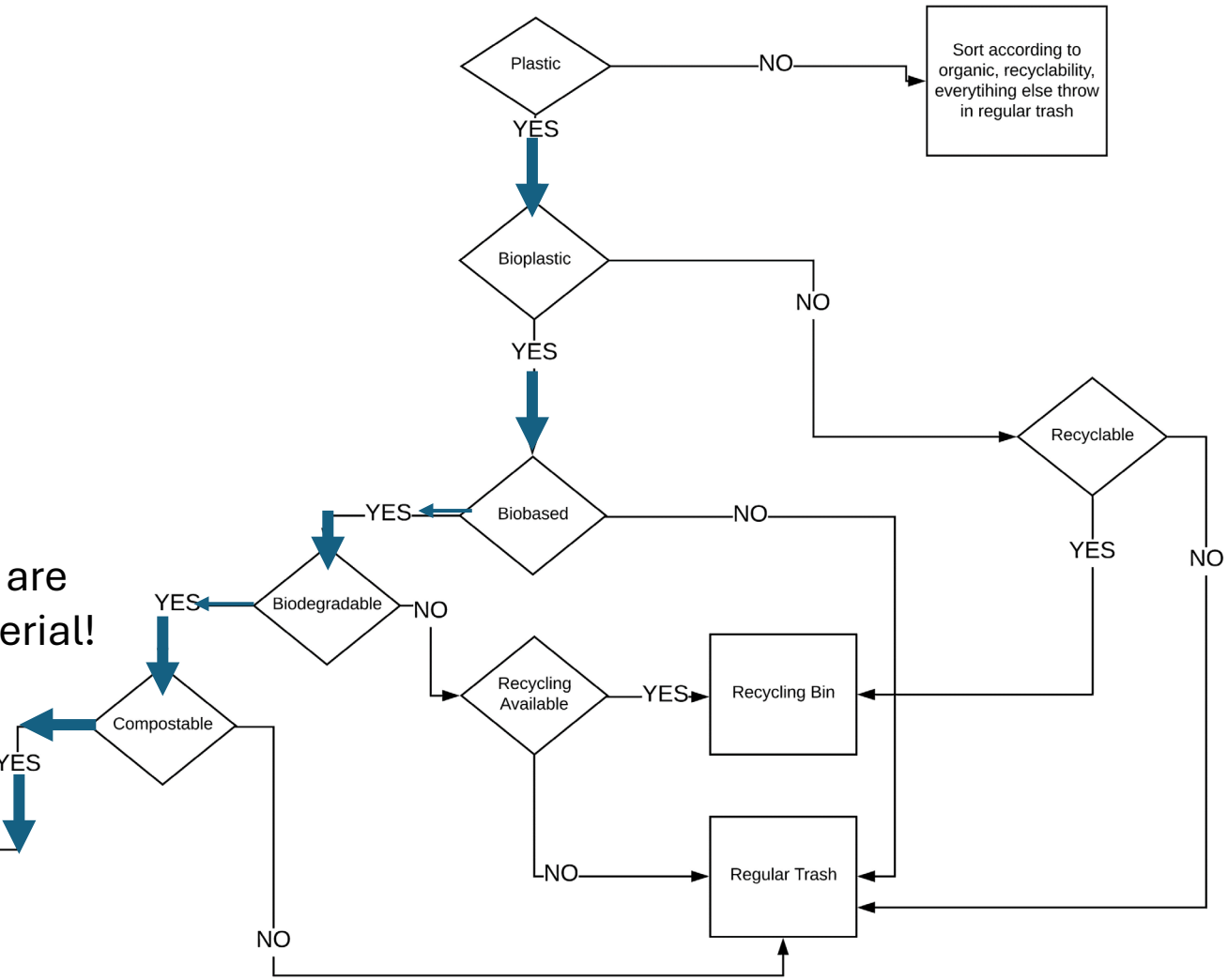
Idealized Disposal Thought Process

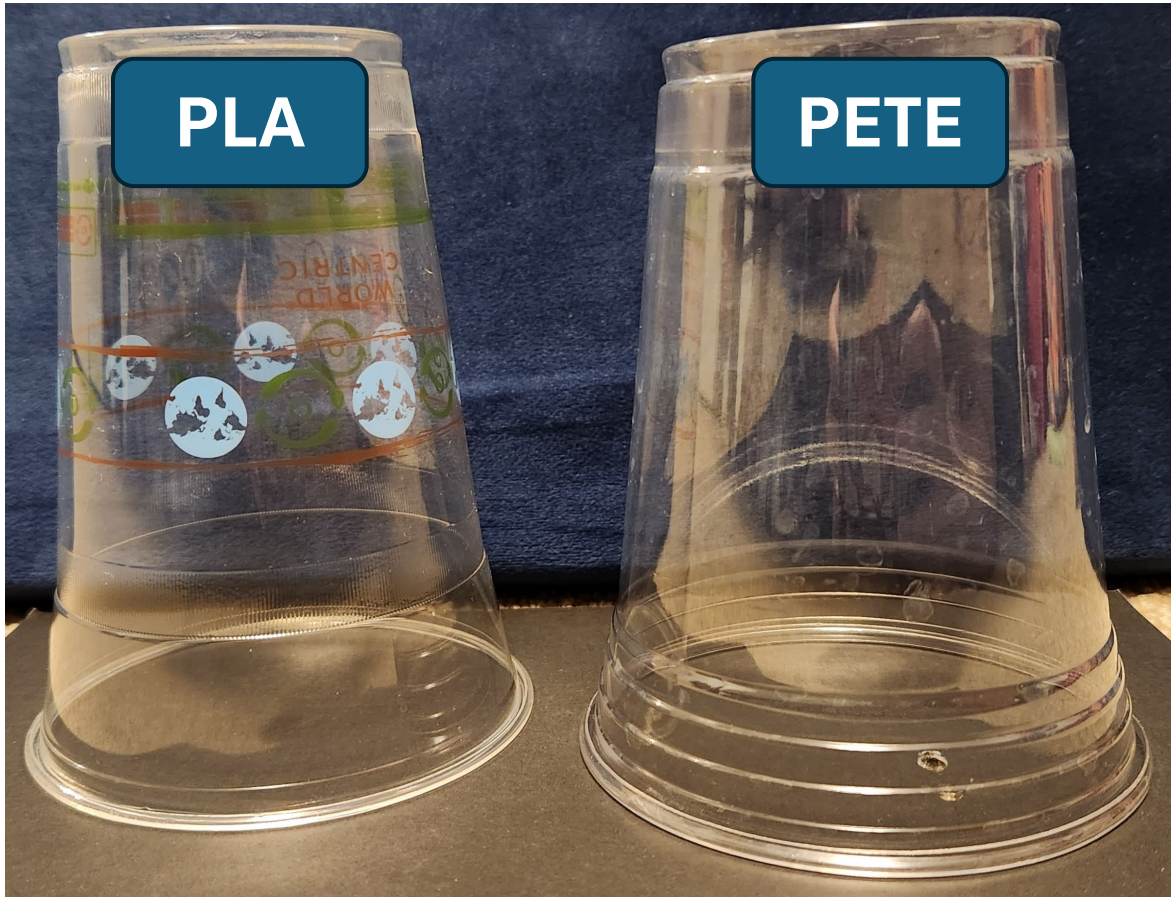


Idealized Disposal Thought Process

BUT most composters are not accepting this material!

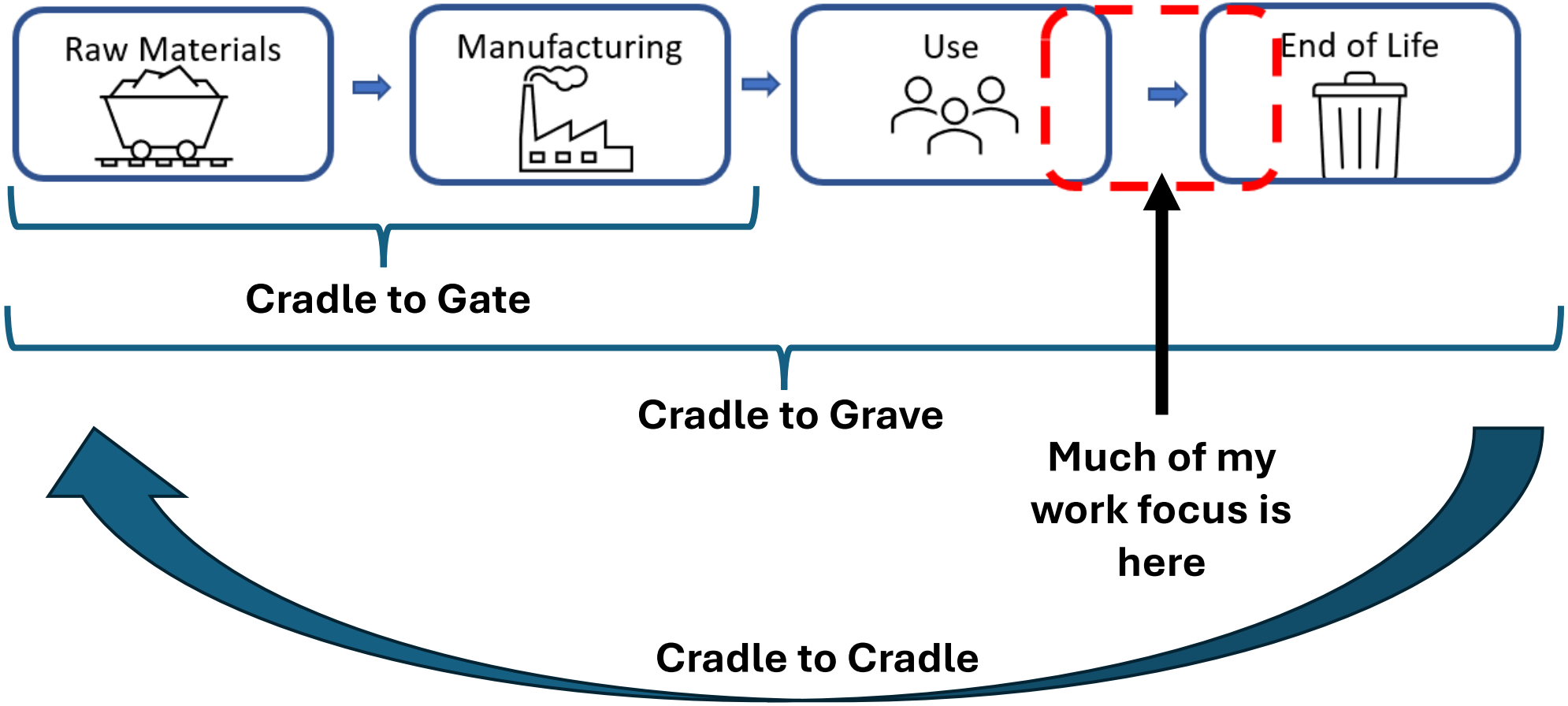


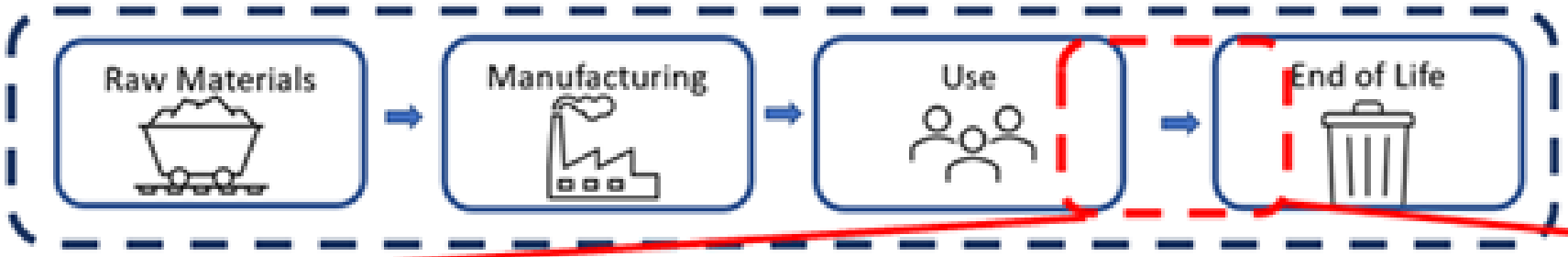




We can use ***life cycle assessment (LCA)*** to compare bioplastics with conventional plastics to determine if they are in fact worth it

Life Cycle Assessment (LCA) Stages





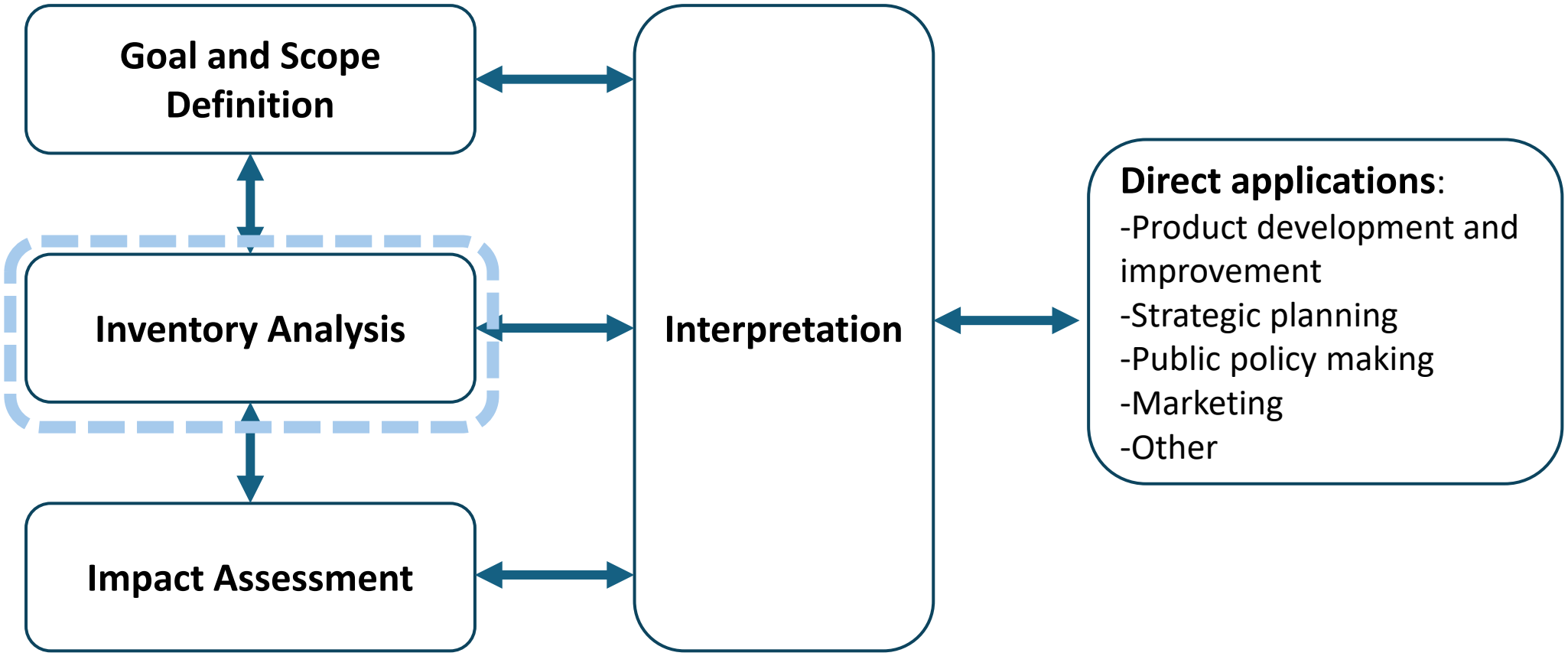
Human behavior affects the use and end of life of a product and consequently, the potential ***environmental impacts*** of the product.

Motivation

- **“Where are the people?,”** in the LCA context (Gutowski, 2018)

- Address the ***gaps in knowledge and data in human behavior*** at the use and disposal phases for single-use plastics and bioplastics.

Life Cycle Assessment Methodology



Adapted from ISO 14040

LCAs of bioplastics that include End of Life (EoL)

Study	Basis Criteria for EoL Scenarios
Potting and van der Harst, 2015	Stylized scenarios
Fieschi and Pretato, 2018	Stylized scenarios
Hottle et al., 2017	Stylized scenarios
Khoo and Tan, 2010	Undetermined
Rattana and Gheewala, 2019	Stylized scenarios
Maga et al., 2019a	Current waste mix and forecast
Maga et al., 2019b	Stylized scenarios, some with literature
Leejarkpai et al., 2016	Stylized scenarios, except one
Moretti et al., 2021	European Mix

None of the LCAs **included human behavior**, most included stylized scenarios or waste mix

(Rodriguez Morris and Hicks, 2022)

Studies of Human Behavior of Disposal of Bioplastics

Study	Method
Minelgaite and Liobikiene, 2019	Telephone Survey
Hsieh et al., 2019	In person survey after patrons finished meal
Brouwer et al., 2018	Material flow analysis
Ansink et al., 2019	Field experiment
Klein et al., 2019	Online survey
Dilkes-Hoffman et al., 2019	Online survey
Taufik et al., 2020	Lab-in-the-field experiment
Herbes et al., 2020	Online and face to face interviews
Langley et al., 2011	Mixed methods

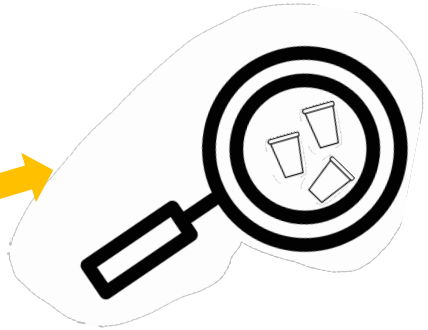
Most are survey work, some are experimental/observational, **all include intervention** with subjects and the only audit was conducted by participants themselves which may lead to biases.

(Rodriguez Morris and Hicks, 2022)

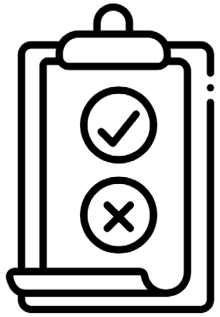
Consumers dispose of cups. There is neither observation of nor interaction with consumers.

Custodial staff collect bags while keeping the waste and recycling streams separate.

Custodial staff place bags in designated areas for each stream.



Authors and students audit waste while keeping cups from each stream separate.



Authors record cup types and amounts found per waste stream per trial.

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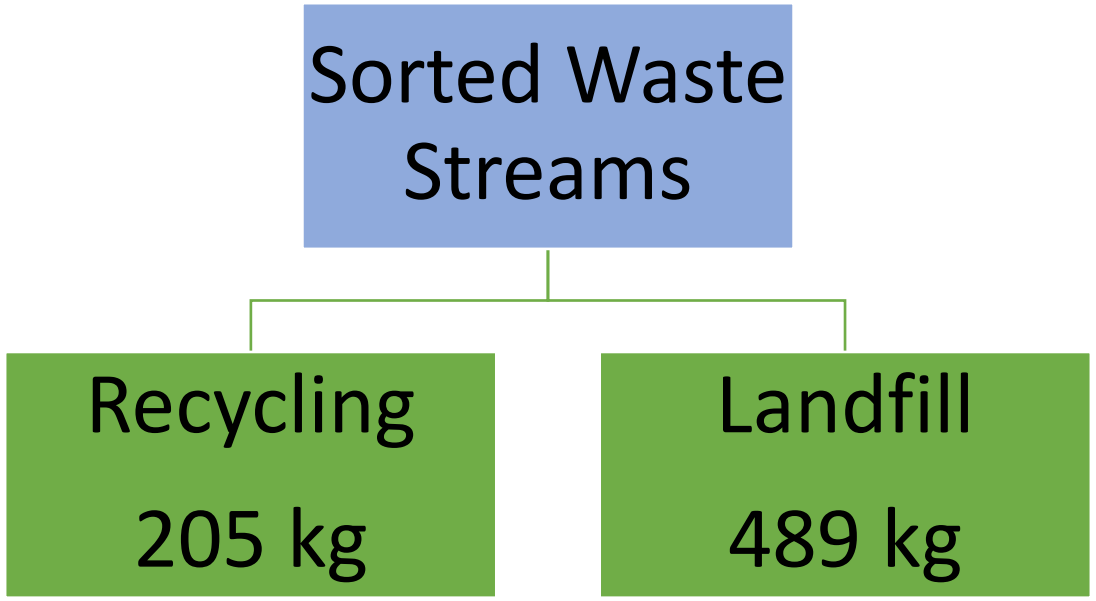
We focused on one polymer application/product,

beverage cups for cold drinks



Plastic Cups Sorted (1,078 total)

- Polylactic Acid (PLA)-143 cups
- Polyethylene Terephthalate (PETE)-725 cups
- Polypropylene (PP)-106 cups
- Polysterene (PS)-104 cups

Trial 1
Sept. 2021

→

Trials 2 & 3
Dec. 2021

→

Trials 4 & 5
Apr. 2022

→

Trials 6, 7 & 8
Dec. 2022

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CARDBOARD &

Disposal Outcomes

Table 1. "Correct" disposal outcomes.

Material	Recycling	Landfill
PETE	Correct	Incorrect
PP	Correct	Incorrect
PS	Correct	Incorrect
PLA	Incorrect	Correct

Let's hypothesize:

Do you think people will be better at sorting one material versus the others?

If so, which material do you think people will be better at sorting?

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Disposal Outcomes

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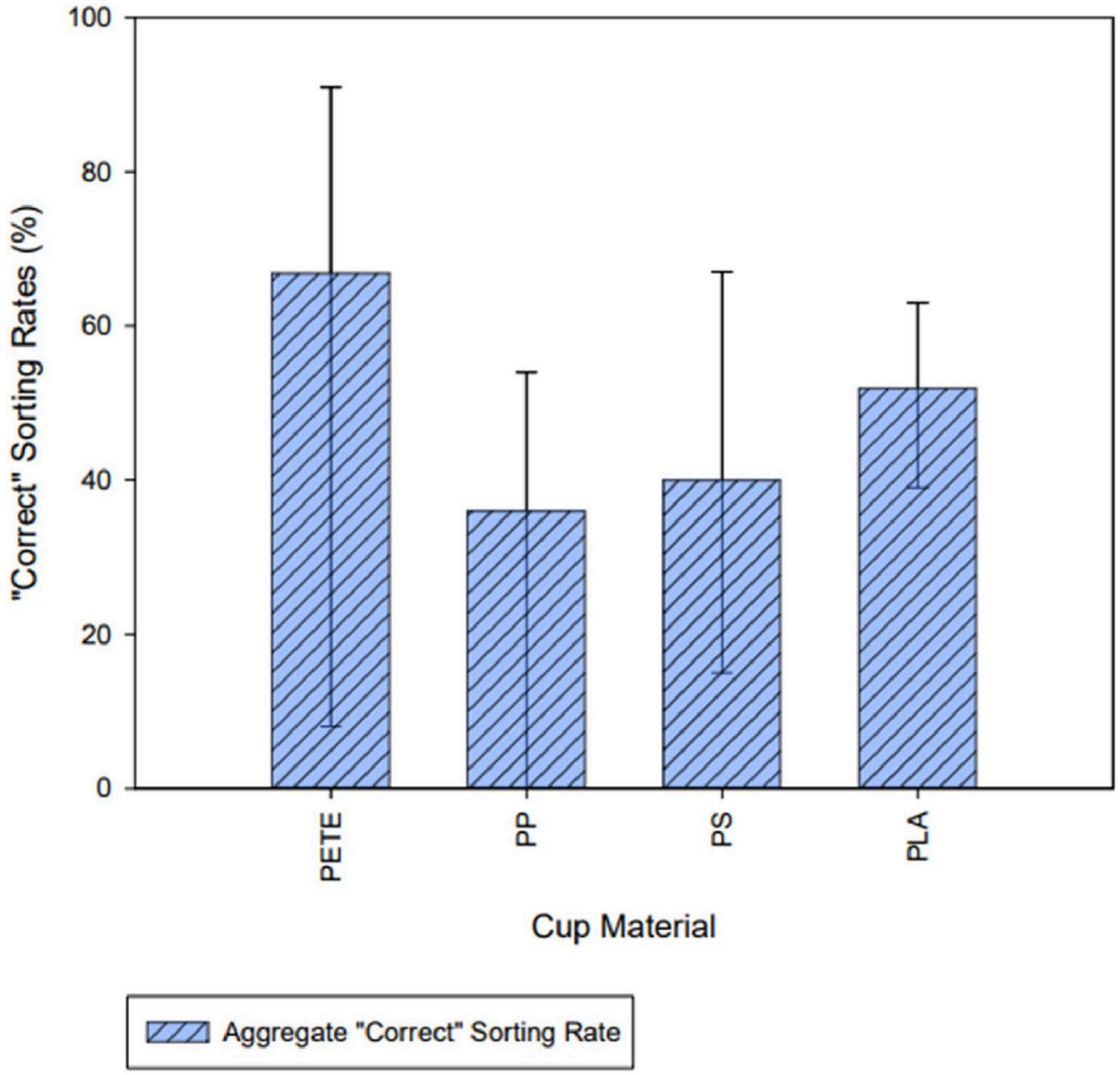

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Literature of behavior at point of disposal of bioplastic

This study	**2023**	**52% PLA cup in landfill waste (correct), 67% PETE cup in recycling (correct), 36% PP cup in recycling (correct), 40% PETE cup in recycling (correct),**	**Waste Audit**
Ansink et al.	2022	90% compostable cup in plastics* bin (incorrect)	Field Experiment
Closed Loop Partners	2023	28% compostable** packaging in recycling (incorrect)	Digital Survey
Dilkes-Hoffman et al.	2019	62% biodegradable plastic in the recycling bin (not specified as "correct" or "incorrect" in study context)	Online Survey
Taufik et al	2020	89% fossil based plastic packaging in recycling (correct), 81% recyclable bio-based plastic packaging in recycling (correct), 37% compostable bio-based plastic packaging in organic waste (correct)	Lab-in-the-field Experiment

*Three types of bins available.
** Compostable packaging included PLA and other materials labeled as compostable.

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Binomial Test

P(disposing in recycling)

=

P(disposing in landfill)

	PETE	PP	PS	PLA
Trial 1	YES	-	-	NO
Trial 2	YES	-	NO	NO
Trial 3	YES	-	NO	NO
Trial 4	-	YES	-	-
Trial 5	-	NO	YES	-
Trial 6	NO	-	-	-
Trial 7	YES	-	-	-
Trial 8	YES	-	-	-
Total	YES	YES	YES	NO

Yes = rejected

If rejected, the probabilities are not equal, and there is a preference for one type of bin.

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Limitations

- Limited geographic and demographic sample.
- Only one type of plastic product application was considered.
- Only two types of waste bin streams were offered during the study.

Conclusion

- People seem to prefer the correct outcome for PETE, but for other materials, disposal outcomes seem to be random.

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- The implications may mean that results of previous LCAs could change depending on what really ends up being recycled or in the landfill.

Acknowledgments

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