Navigating the Unknown: Ambiguity, Uncertainty, & Students' Tolerance in Capstone (WIP)

Hrushi Godbole (The Ohio State University) & Beth DeBartolo (Rochester Institute of Technology)

Capstone projects expose students to ambiguity and uncertainty inherent in real-world engineering work. This work distinguishes ambiguity from uncertainty in capstone design, identifies where each arises, and re-evaluates existing instruments for measuring students' tolerance. Results show distinct origins, moderate correlation, and limitations in commonly used ambiguity measures.

Motivation & Background

- Engineering graduates must navigate ill-structured, ambiguous problems in professional practice
- Engineering education must foster qualities such as tolerance for ambiguity and adaptability, which transcend traditional engineering learning outcomes (Atman 2010)
- Capstone courses provide a structured environment where students encounter unclear problem definitions, evolving constraints, and incomplete information
- Prior work suggests that students' ability to tolerate ambiguity and uncertainty affects learning and design performance

Research Question

1. What distinguishes ambiguity from uncertainty in engineering capstone design, and in what project contexts does each arise?
2. How can tolerance to ambiguity (TA) and tolerance to uncertainty (TU) be measured in capstone students?

Ambiguity vs Uncertainty

- Uncertainty describes situations where the parameters of the problem are known, but their exact values are not defined (Schrader 1993)
- Ambiguity describes situations where the structure of the problem is unclear, including relevant parameters, how they relate to one another, and what procedure should be used to reach a solution (Schrader 1993)
- Scales to measure these constructs:
  - "Why People Worry" uncertainty scale (Freeston)
  - Tolerance of Ambiguity scale (Budner)
  - Many alternative instruments available to measure TA (Furnham & Marks 2013)

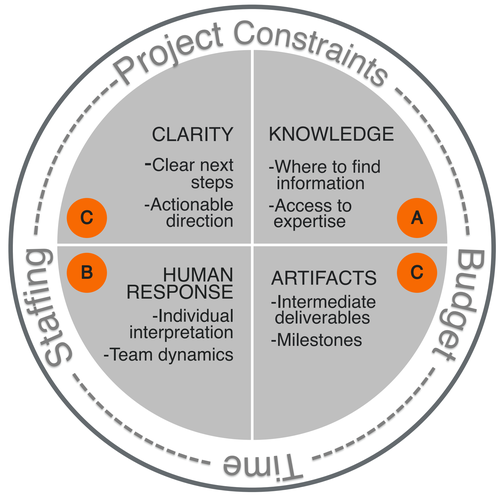
Observed Ambiguity & Uncertainty

Instructor interviews revealed that ambiguity and uncertainty were risk factors preventing positive student learning outcomes (Godbole 2025)

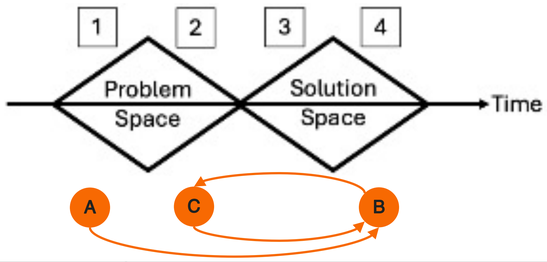
Example: During a medical device development, project client reported applying "medium force" during surgery

- **A** **Problem Ambiguity**: Is hospital liaison or the surgeon is primary client? Perceived lack of access to information and expertise.
- **B** **Solution Uncertainty**: arising from vague feedback by client on the prototypes leading to frustration within the student team
- **C** **Problem Uncertainty**: What is a "medium amount of force?" arising from undefined intermediate artifact (measurement gauge)

Factors affecting Ambiguity & Uncertainty



Sequential Resolution of Ambiguity & Uncertainty



1	Problem Ambiguity	Stakeholder interviews, site visits, root cause analysis, user journey maps
2	Problem Uncertainty	Benchmarking, prototyping, patent review, specification development
3	Solution Ambiguity	Sketching, Prototyping, Pugh matrix, DFX methods, A/B testing, Simulation Modelling
4	Solution Uncertainty	Detail design, FMEA, Validation testing, System Integration, Fabrication, Optimization

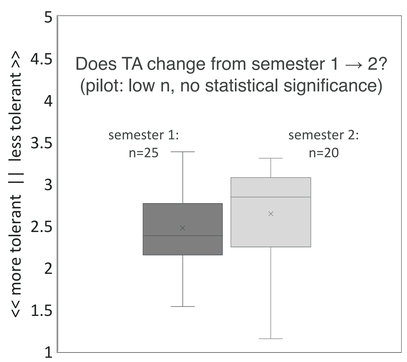
Findings from RQ 1

- Ambiguity and uncertainty may not be perceived sequentially. However, sequential resolution reduces unnecessary iterations and frustration.
- Capstone courses provide a structured environment where students encounter unclear problem definitions, evolving constraints, and incomplete information
- Ambiguity and uncertainty arise from lack of action clarity, lack of knowledge access, unknown intermediate artifacts, and human response

TA Instrument	alpha
Budner's Instrument	0.44
Novelty	0.20
Insolubility	0.25
Complexity	0.36
Herman's Reduction	0.52
Pilot: MSTAT - II	**0.81**

Findings from RQ 2

- Budner's instrument & its subscales have low Cronbach's Alpha
- Herman's reduction: marginally better
- Moderate correlation between TA (Herman's reduction) and TU
  - Pearson's coefficient: 0.416
- MSTAT-II pilot is promising due to:
  - Shorter survey length
  - Improved Cronbach's alpha



Conclusion

- Ambiguity and uncertainty are distinct but coupled concepts in design projects with a moderate correlation
- The proposed four-phase framework provides a useful interpretive lens for understanding progression from problem formulation to solution validation
- Initial formulation of four themes that lead to perception of ambiguity & uncertainty among capstone students
- MSTAT-II is a promising alternative to measure TA

Future Work

- Administer MSTAT-II to 2026-27 capstone students across multiple colleges
- Investigate pre- and post- capstone changes to TA
- Investigate correlations between TA and course learning outcomes
- Interview experienced capstone instructors to develop a library of legacy interventions that are anecdotally effective to overcome specific types of ambiguity and uncertainty

Get Involved

- We seek participation of other capstone programs to administer a 3-minute survey to their students for more robust insights
- Please use the QR link below to connect

Please refer to open-access conference paper on capstone design community website for full references

The Ohio State University
College of Engineering

RIT Kate Gleason College of Engineering
Multidisciplinary Senior Design