Exploring micro-, meso-, and macro- thriving in engineering: Implications for engineering education and engineering ethics

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Abstract

This research explores and advocates for including engineering thriving as a crucial component of engineering ethics education with implications at the micro-, meso-, and macro- levels. Engineering directly impacts the thriving of society and organizations, yet the education of engineering students is not known for thriving (yet). Prior work on engineering thriving has largely focused on the micro-level (individual) and meso-level (organizations) with little focus on the macro-level (social institutions). This research focuses on key considerations when educating engineering students to become moral agents of technological change that drive wealth and wellbeing.

Research Questions

- How can we define thriving at each level of the engineering education ecosystem as well as provide a shared language around indicators of thriving at each level?
- How does thriving function at each level, and how is thriving influenced between and among levels?

Purpose

- Introduce the boundaries and key considerations between micro-thriving, meso-thriving, and macro-thriving
- Advocate for the importance of engineering thriving considerations within engineering ethics education at each of the three levels

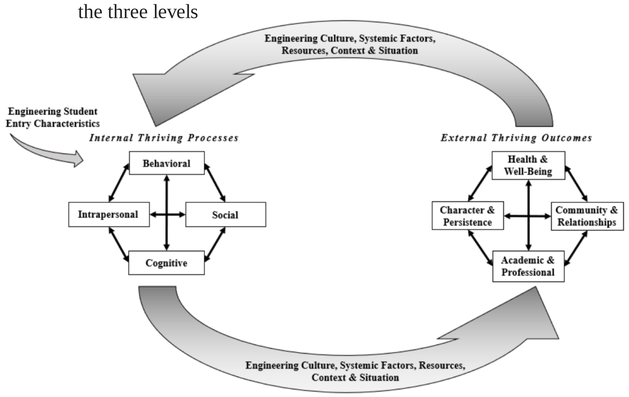

Figure 1. Model of engineering thriving, from [1], which focuses on the Micro-level (individual) and Meso-level (organizations)

Hypothesis

If we perform a systematized literature review on engineering thriving at the levels of Micro, Meso, and Macro, we will be able to determine the indicators of thriving at each level.

Systematized Literature Review

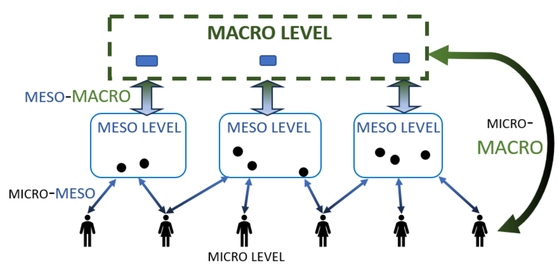

Figure 2. Generalized Micro-Meso-Macro Framework. Adapted from [2]. The framework consists of three levels (Micro, Meso, and Macro) and three influence paths (Micro-Meso, Meso-Macro, and Micro-Macro). Influences flow bidirectionally. To maintain readability, only one Micro-Macro influence path is shown and only one Micro-level is labeled.

Table 1. Characteristics of 29 Papers included in the Analysis

Number of Journal Papers	11
Number of Conference Proceedings	18
Publication Date Range	2002-2023
Number of Journals Represented	6
Number of Conferences Represented	11

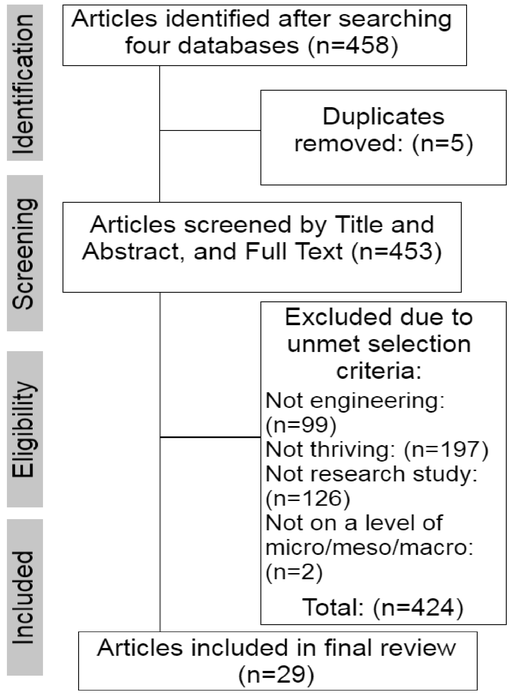

Figure 3. PRISMA Diagram Outline Review Process for Papers

Results

Micro

- Motivation [3]
- Academic Performance [4]
- Confidence [5]
- Mindfulness [6]
- Self-awareness [7]
- Ability to work in a team [5]
- Problem-solving skills [6]
- Communication skills [8]

Meso

- Collaborative learning environment [9]
- Student and faculty morale [10]
- Increased number of university resources [8]
- Faculty accessibility [11]
- Student-teacher ratio [11]

Macro

- Diversity in engineering as a profession [12]
- Diversity in leadership positions [13]
- Affordability of education [5]
- Awareness of macro-ethical consequences of micro-ethical actions [14]

Figure 4. Indicators of Thriving at the Micro, Meso, and Macro-levels

Micro-Macro

- Engineering Ethics Education connects Macro-ethical results to Micro-ethical decisions [14]
- Individual response to global events (e.g., COVID-19) [15]

Meso-Macro

- Institutions can provide greater access to university resources and academic enrichment programs to increase students' confidence and willingness to learn [16]

Micro-Meso

- A country's government can change the requirements of its engineering programs to better foster creativity, problem-solving skills, and collaboration skills [17]

Figure 5. Engineering Thriving Influences Between the Micro, Meso, and Macro Levels (Paths)

Implications

Table 2. Recommendations for Engineering Educators with Basis in Complex Systems Science

Recommendation	Basis
When measuring or making efforts to improve thriving, the level of intervention (Micro,Meso,Macro) should be informed by the time available and urgency of change.	Implication 1: The speed of the dynamics for each level slows as each level becomes larger. Micro is generally the fastest, while Macro is the slowest.
When planning interventions to increase thriving, be aware that influences between levels are difficult to predict. For example, Do not simply attempt to increase Micro thriving in order to improve Meso or Macro thriving.	Implication 2: Flows between levels are difficult to predict.
If, however, you have limited resources to increase thriving and must pick one level to focus on, focus on the Meso level as this is the most likely to impact the Micro and Macro levels as well.	Implication 3: The Meso level holds a unique role in that it influences Micro and the Macro level. It is the most susceptible to intervention.

Conclusion

- We provide a definition of thriving at each of the levels in the engineering education ecosystem. This contribution provides a shared language as well as a list of indicators of thriving at each level.
- We examine the influence of thriving between levels by considering thriving an emergent property of the Meso and Macro levels. By mapping influence paths between the levels, this work lays the foundation for future work that seeks to identify specific strategies to increase thriving.
- The qualities of ethical reasoning and actions develop through thriving interactions (Micro), under favorable environments (Meso), which enables more thriving societies (Macro).

Future Work

- Identify specific strategies and interventions to increase thriving at each level.
- Formalize thriving indicators and create formal evaluation methods.

Citations

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