Collaborative Opportunity: Growing a Community around Integrated Engineering

Rebecca Bates
Minnesota State University, Mankato, USA, bates@mnsu.edu

Emanuela Tilley
University College London, UK, e.tilley@ucl.ac.uk

Jenna Carpenter
Campbell University, USA, carpenter@campbell.edu

Susan Lord
University of San Diego, USA, slord@sandiego.edu

Abstract

Integrated Engineering is emerging across the world. One commonality among programs is a desire to innovate in ways not seen as possible within traditional engineering disciplines. The inclusive pedagogical approaches seen in integrated engineering programs offer promise for truly transforming engineering education. These student-centered approaches align with caring pedagogies and provide sustainable infrastructure for supporting diverse student experiences. Innovation in engineering education can be challenging to implement and can be challenging to sustain. Community support can make a positive difference. Building on a series of community conversations at multiple international conferences as well as an international symposium in London during the summer of 2024, this paper will be used to spark a conversation about innovations related to integrated engineering. The goal is to include new voices to extend the existing community, build a stronger network, and provide an opportunity to reflect and plan implementation steps for enacting holistic approaches to engineering education.

Keywords: Integrated engineering, holistic pedagogies, community engagement

1 Context & Purpose

Integrated Engineering is emerging across the world (Graham, 2018). One commonality among programs is a desire to innovate in ways not seen as possible within traditional engineering disciplines. The variation in implementations is a strength in contrast to the homogeneity of traditional engineering disciplines. The inclusive pedagogical approaches seen in integrated engineering programs, including project-based, enquiry-based, skill-based, and work-based experiences, offer promise for truly transforming engineering education. These student-centered approaches align with caring pedagogies and provide sustainable infrastructure for supporting diverse student experiences. Any conversation about integrated engineering thus addresses three of the core themes of the conference: Caring Pedagogies and Sustainable Education, Community Engagement, and Creative Futures.

Innovation in engineering education can be challenging to implement and can be challenging to sustain. Community support can make a positive difference, especially for isolated innovators. Building on a series of community conversations at European Society for Engineering Education (SEFI), Frontiers in Education (FIE), and the American Society for Engineering Education (ASEE) conferences (Bates et al, 2022) as well as an international symposium in London during summer of 2024 (Tilley, 2024), the goal of this work is to present information about past interactions and spark ongoing conversation with new participants. In particular, the conversation can examine ways that current and planned innovations relate to integrated engineering, which can functionally be defined as integrating into engineering education a broad range of concepts, skills, motivations, and learning processes. The focus is on including new voices in the conversation to extend the existing community of people and institutions leading the way for a modernised approach to engineering education worldwide, building a stronger network, and providing an opportunity to reflect and plan implementation steps for enacting holistic approaches to engineering education with a supportive community.

2 Approach

The 2024 Symposium resulted in robust descriptions of experiences and aspirations from 30 programs across 13 countries. Analysis and clustering of these is in progress; however, the initial results indicate key questions for next steps (Tilley, 2025). In parallel, work in the United States to address ways to bring about a more

inclusive mindset within engineering education culminated in a report calling institutions and educators to action (Bertoline, 2024). The six recommendations from the ASEE Inclusive Engineering Mindset report include:

1. Create flexible program structures to remove barriers
2. Use evidence-based pedagogy: Creating a student-centered engineering education
3. Create an accessible and diverse engineering education learning environment
4. Prepare campuses for a student-centered engineering education
5. Leverage strategic partnerships
6. Engineer a new mindset for engineering education

While the context of the Inclusive Mindset report is within the USA, the basic recommendations are broadly applicable for innovations. Our call for integrating concepts, skills, motivations, and learning processes aligns with these recommendations and points to some of the challenges people have with actually implementing innovations that are contextually important.

The ten questions identified by Symposium participants for next steps correlate strongly with the six recommendations from the Inclusive Mindset report, while focusing on how to keep moving towards better experiences for students and faculty alike. The idea of an inclusive, accessible, and diverse learning environment is foundational for all integrated engineering programs (*Mindset 3*).

1. How do we shift from isolated initiatives to systemic transformation? *Mindset 4, 5, 6*
    - Change often starts with individuals or experimental programmes—but how do institutions scale and sustain integration across entire faculties or universities?
2. What narratives do we use to inspire and sustain change? *Mindset 6*
    - Storytelling about real student and community impact is essential for gaining support, shifting mindsets, and bridging silos.
3. How do we balance the need for speed with the necessity of trust-building? *Mindset 4, 6*
    - Institutions face pressure to act quickly, but integration requires slowing down to engage, listen, and co-create with diverse stakeholders.
4. What support structures are needed to legitimise pedagogical experimentation? *Mindset 1, 2, 4*
    - Educators need time, protection, and recognition to innovate—especially when working against traditional norms of teaching and research excellence.
5. How do we reframe resistance as a productive force in change? *Mindset 4, 5*
    - Tensions and discomfort should not be avoided but embraced as part of a deeper learning and institutional growth process.
6. How do we build distributed and shared leadership? *Mindset 4, 5*
    - Avoiding heroic narratives, change must be collective, networked, and sustained through communities of practice rather than top-down mandates.
7. What does a truly inclusive and context-aware change process look like? *Mindset 6*
    - Leadership must honour the diversity of institutional cultures, faculty identities, and local communities, recognising there is no one-size-fits-all path.
8. How can we redefine excellence and realign reward structures? *Mindset 4*
    - Promotion and evaluation systems need to value interdisciplinary, community-engaged, and integrative teaching and research.
9. How do we cultivate and support staff capacity for integration? *Mindset 1, 4*
    - Faculty and professional staff need ongoing development, peer support, and access to collaborative spaces that foster integrative pedagogy.
10. Are we preparing for the next generation, not just the next academic year? *Mindset 1, 2, 3, 4, 5, 6*
    - Change must be intergenerational, patient, and purpose-driven—focused on shaping future-ready institutions and graduates.

These findings are presented as foundational context for a longer conversation about potential next steps that can be taken to further explore holistic approaches inspired by the outcomes. It is hoped that conversations will allow participants to 1) consider the ideas presented (as well as inspirational ideas from the rest of the conference), 2) connect these ideas to their local context, 3) brainstorm ways to implement components that resonate with them, and 4) build connections to and within a larger network of support.

Examples of "integrated engineering" that facilitate a broad range of positive experiences from students can be seen from the integration experiences of the authors (Bates, Pluskwik and Ulseth, 2020; Bates, et al., 2024; Bertoline, 2024; Bertoline, 2025; Carpenter and Rynearson, 2017; Gelles and Lord, 2021; Lord, Przestrzelski and Reddy 2019; Mitchell, Nyamapfene, Roach, and Tilley, 2021 and 2019; Spence et al., 2022) and others who participated in the Symposium (e.g., Smith et al., 2024; Magnell, Geschwind, and Kolmos, 2016; Ford and Riley, 2003; Langie and Craps, 2020; National Academies of Sciences, Engineering, and Medicine, 2018). These include curricula that provide a variety of options, multidisciplinary experiences driven by student interests, project-based experiences at multiple education levels, connecting a sense of vocation and purpose to engineering learning, connections to industry experiences, and strong respect for students, their goals, and their interests.

3 Anticipated Outcomes

The ideas and concepts that will be used as the starting point for conversation include information about aspirations and challenges for education innovation. Participants in the 2024 Symposium included programs that have been running for over a decade as well as programs that are in initial stages of transformation. Some of the US participants worked with a larger team to create a blueprint for action that provides further examples of change processes for innovation in engineering education (Bertoline, 2025). These points, both constructive and cautionary, gathered from many nations, can be used as guideposts, inspiration, and a shared sense of experiences for participants, whether they are experienced innovators or new to the challenge of change in engineering education.

We plan to participate in conversations about ways to support not just change in individual teaching practice but program-level transformation that provides infrastructure for sustained changes in individual teaching and learning experiences. In the context of the IRSPBL Anchoring Conversations conference, this paper provides supportive content for reflection and planning, which can increase the impact of experience. We welcome a wide range of voices in this conversation and hope to include people who can share their stories of innovation as well as people who are just getting started. These stories can be captured and shared at the new Integrated Engineering website (integratedengineering.org).

4 Summary

Because of open-ended conversations related to this material, we hope participants and readers will have at least one concrete action planned as well as new connections to others who are implementing change. These connections should strengthen and expand an existing network of engineering educators working to create sustainable educational experiences that focus on students, that include faculty holistically, and that will be of support as they return to their home institution.

5 References

Bates, R., Lord, S., Tilley, E., & Carpenter, J. (2022). A Community Framing of Integrated Engineering. Paper presented at *2022 American Society for Engineering Education Annual Conference & Exposition*, Minneapolis, MN. https://peer.asee.org/41248

Bates, R., Pluskwik, E. & Ulseth, R.(2020). Startup of an Innovative Program x3 – Iron Range Engineering Propagated. *2020 IEEE Frontiers in Education Conference (FIE),* Uppsala, 2020, pp. 1-4, doi: 10.1109/FIE44824.2020.9274291.

Bates, R., Ulseth, R., Mann, C. & Chase, L. (2024). Moving from Industry-sponsored Academic Projects to Supporting Student Learning in Industry. In *Approaches to Work-Based Learning in Higher Education: Improving Graduate Employability*, Matthew Barr, ed. London, UK: Routledge.

Bertoline, G.R., Ed. (2024). The Inclusive Engineering Mindset: A Vision for Change in Undergraduate Engineering and Engineering Technology Education. Washington, DC: American Society for Engineering Education. Available at https://mindset.asee.org.

Bertoline, G.R., Ed. (2025). The Engineering Mindset - Blueprint for Change, Vols. 1 and 2. Washington, DC: American Society for Engineering Education. Available at https://mindset.asee.org.

Carpenter, J.P., & Rynearson, L.K. (2017). Design of Classlab and Supporting Spaces to Enable a Multidisciplinary Hands-on First-Year Engineering Design Curriculum. Paper presented at *2017 American Society for Engineering Education Conference & Exposition,* Columbus, Ohio. https://peer/asee/org/28120

Ford, J.D., & Riley. L.A. (2003). Integrating Communication and Engineering Education: A Look at Curricula, Courses, and Support Systems. *Journal of Engineering Education (Washington, D.C.)*, *92*(4), 325–328. https://doi.org/10.1002/j.2168-9830.2003.tb00776.x

Gelles, L.A., & Lord, S.M. (2021) Pedagogical Considerations and Challenges for Sociotechnical Integration within a Materials Science Class, *International Journal of Engineering Education*, vol. 37, no. 5, 1244 - 1260.

Graham, R. (2018). *Global State of the Art Report in Engineering Education,* https://jwel.mit.edu/assets/document/global-state-art-engineering-education.

Langie, G., & Craps, S. (2020). Professional competencies in engineering education: the PREFERed-way. *Információs Társadalom* XX, no. 2 (2020): 142–153. *https://dx.doi.org/10.22503/inftars.XX.2020.2.10*

Lord, S. M., Przestrzelski, B. & Reddy, E. (2019). Teaching social responsibility in a Circuits course. Paper presented at *2019 American Society for Engineering Education Annual Conference & Exposition*, Tampa, FL. https://peer.asee.org/33354

Magnell, M., Geschwind, L., & Kolmos, A. (2016). Faculty perspectives on the inclusion of work-related learning in engineering curricula, *European Journal of Engineering Education*, doi:10.1080/03043797.2016.1250067

Mitchell, J. E., Nyamapfene, A., Roach, K., & Tilley, E. (2021). Faculty wide curriculum reform: the integrated engineering programme, *European Journal of Engineering Education*. doi:10.1080/03043797.2019.1593324

Mitchell, J.E., Nyamapfene, A., Roach, K., & Tilley, E. (2019). Philosophies and pedagogies that shape an integrated engineering programme, *Higher Education Pedagogies*, vol. 4, no. 1, pp. 180-196, 2019. doi:10.1080/23752696.2018.1507624

National Academies of Sciences, Engineering, and Medicine. (2018). *The Integration of the Humanities and Arts with Sciences, Engineering, and Medicine in Higher Education: Branches from the Same Tree.* Washington, DC: The National Academies Press. https://doi.org/10.17226/24988

Spence, S., Christensen, D., Sleezer, R., Nelson, J., Walerius, R., Johnson, R., & Bates, R. (2022). An Integrated Engineering Model for Advising, Paper presented at *2022 ASEE Annual Conference & Exposition*, Minneapolis, MN. https://peer.asee.org/41601

Smith, E., Pardo, A., Mills, J., & Birbeck, D. (2024). Curriculum renewal to enhance the acquisition of professional skills and engagement with professional practice across engineering programs. *Australasian Journal of Engineering Education.*, *29*(2), 154–165. https://doi.org/10.1080/22054952.2024.2381144

Tilley, E. (2025). *Our Stories of Change: Towards A Global Call for Integrated Engineering Education,* https://www.integratedengineering.org/docs/IEEIS_White_Paper_final_public.pdf.