



STEM research as a framework to reimagine undergraduate STEM education using the TrI Model

Introduction

The future of undergraduate STEM education (USE) needs a framework that makes it just as research-based and evidence-based as STEM research. To meet the needs of students, science, and society, USE needs to emulate cutting-edge STEM research. STEM research is theoretically sound, intensely evidence-based, and incredibly iterative. USE can and must be the same!

The most cutting-edge STEM research of today (and tomorrow) is built on empirically validated theoretical principles. The future of USE must do the same by leveraging all that we are discovering about how people learn. Advances in developmental cognitive psychology, neuroscience, and the learning sciences are illuminating the once opaque experience of human learning. Previously assumed notions of learners as “tabula rasa” or “blank slates” that simply absorb information are being replaced with theoretically backed understandings of learners as active constructors of knowledge. We must leverage the science behind learning to propel our theories of learning forward.

With a sound theoretical foundation, we can apply our understanding of learning to develop evidence of what works (and what does not) when it comes to USE. Again, claims in STEM research absolutely require evidence, usually in the form of experimental data. Why can’t we view USE in the exact same light? We need to have resources and expertise in place to conduct discipline-based education research at scale. And just like in STEM research, conclusions from this type of research need to be replicated and enhanced with future studies. Thus, the incredibly iterative nature of STEM research must also be a hallmark of USE. Overall, USE has a fantastic model of innovation right next to it! We must use it to our full advantage.

The TrI Model

Importantly, enacting this STEM research framework requires an orientation for the future. For example, many of the STEM jobs of the future do not currently exist. How can we possibly prepare the STEM undergraduates of tomorrow for a seemingly unclear and unknown future? By envisioning a future USE based on the TrI Model.

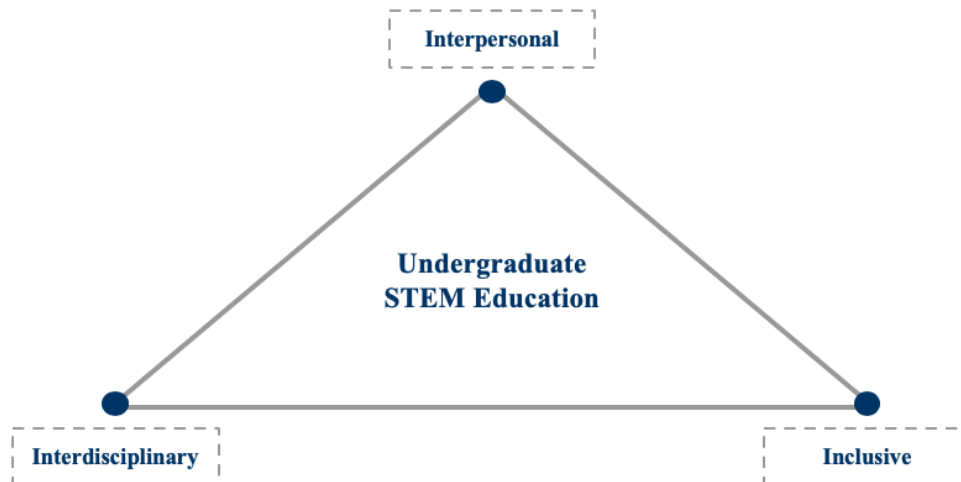


Figure 1: The TrI (Interpersonal, Interdisciplinary, Inclusive) Model

The future of USE must be **Interpersonal**.

The notion of the “lone scientist” or the “lone genius” has evaporated. Look at any landmark STEM publications of the past decade or two. There are always multiple authors. Science has become interpersonal. Collaboration is no longer a luxury—it is a necessity. USE must be the same way. Learners need to work on the STEM problems of today and tomorrow together, much like STEM professionals already do. This interpersonal collaboration needs to start as early as possible, especially in gateway introductory STEM courses. The prevailing experience of a solitary student completing solitary assignments and assessments distorts students’ perceptions of STEM, and therefore, must be enhanced with opportunities for collaborative, project-based learning.

The future of USE must be **Interdisciplinary**.

Again, looking at the cutting-edge STEM research of today, publications are becoming more and more interdisciplinary, both within and across institutions. Seemingly disparate fields of STEM are becoming so much more integrative because the world’s most complex problems require interdisciplinary perspectives. USE of the future must be the same. For example, the notion of “majors” and “non-majors” science courses artificially separates diverse perspectives, creating barriers to interdisciplinary education. Such barriers need to be dismantled in order to get diverse learners to collaborate and learn from each other through mutualistic teaming.

The future of USE must be **Inclusive**.

Despite all the potential of aligning USE with the cognitive model of STEM research, this alignment is bound to fail if the affective side of learning is not part of the equation. Just as our understanding of learning has



changed, our understanding of learners themselves must also change so that every learner is a part of an inclusive environment. A student cannot adequately learn if they do not feel like they belong, and historically, USE has not been a place where marginalized and minoritized groups have felt belonged. Once again, the future will require the most diverse perspectives as possible in order to do the most cutting-edge research. Therefore, it is our responsibility to develop a future USE that is not only diverse, but also inclusive, ensuring that diverse perspectives can flourish.

Conclusion

It may seem as though some of these ideas are not all that new. It is likely that you have come across them in some way, shape, or form at some place here or there. However, the novelty of this proposal lays in its framework-based foundation. The overwhelming majority of USE occurs at large, research-intensive universities, led by professors and graduate students who know what it takes to do cutting-edge STEM research. And even USE that is not occurring at large, research-intensive universities is taught by educators who were still trained at such research-intensive institutions. All of this is to say that those who are “on the frontlines” of USE have a distinct familiarity with the aforementioned concepts of this proposal as they relate to STEM research. The future of USE must leverage this familiarity by showing these educators that the task ahead does not require a jarring, total revamping—it requires a reorientation, a reframing of what is already familiar to a new context that is USE. Of course, this reframing is not as simple as just taking what one does in the lab and doing it in the classroom. Just like research training, it will require deliberate practice and much iteration. Teaching, just like research, is a complex and nuanced practice, but because it is a practice, it is a skill that can be improved. This proposal provides a familiar, future-oriented framework modeled for such improvement, allowing us to begin preparing now for the USE of the future.