What follows is a brief history of my efforts to positively impact the undergraduate physics curriculum through supporting and nurturing the practical inclusion of computation. I shall briefly describe my efforts to integrate computation into undergraduate physics and engineering courses for nearly a quarter of a century, and then I shall describe the framework and activities of a burgeoning informal organization-the Partnership for Integration of Computation into Undergraduate Physics (PICPUP)-that I believe can serve as a prototype for building communities that will positively impact STEM education through fostering and supporting the integration of computation into all of the STEM disciplines.

I was fortunate to have been exposed to a computational project in an undergraduate classical mechanics course, and for me it was an invaluable experience in opening my eyes to the vast possibilities of bringing computers to bear on physical problems. The skills and enjoyment I derived from that one undergraduate experience motivated me to include some component of computation in my courses when I began teaching at Bradley University in 1993.

From the beginning, I chose to include computation in my courses in an integrated mode, i.e. one wherein computational approaches to solving physical problems are introduced to students as analytical tools that are just as important as non-computational mathematics. By introducing computation as a natural way (sometimes the only way!) to study the dynamical behavior of a particular system, students see the utility of computation directly in the context of the subject matter they are studying. I found this integrated mode to be more effective for students to learn computational skills than relegating computational education to isolated numerical methods courses that seldom place the computational topics in a proper scientific perspective.

For the first 18 years or so I was at Bradley, I focused my integrating computation effort towards upper level physics courses, specifically, classical mechanics, thermodynamics, and statistical mechanics. In recent years, I have focused on integrating computation into introductory physics courses, as well as into upper level engineering courses, as I'm now part of the College of Engineering at Bradley.

In the neighborhood of 2007, I teamed up with two retired physicists, Norman Chonacky (Yale Applied Physics) and David Winch (Kalamazoo College Physics) to create the aforementioned partnership, PICUP. They had just conducted a national-scale survey [see *Computing in Science and Engineering*, vol. 8, 2006] of the (then current) uses of computation in undergraduate physics courses. The survey clearly demonstrated that there existed a wide-spread openness to computation as an integral part of the physics curriculum, yet, there was a dearth of transformative computational pedagogy. If nearly all physics faculty concede the importance of computation, why has there been little progress in its inclusion in the undergraduate physics curriculum?

PICUP was created in response to this discrepancy, if not disconnect, between physics in STEM professional practices and physics in education, with the following mission

> *"To create a vibrant community of educators, a forum for open discussion, a collection of educational resources, and a set of strategies and tactics that support faculty committed to improving undergraduate physics education through integration of computation into their undergraduate physics courses."*

As a core value, PICUP believes that computational thinking and numerical skills are critical for students to understand complex systems, to analyze data, and to create numerical models and visualizations–all essential aspects of modern science and engineering. Our premise is that any scenario for computational integration must start small but build over 4-year degree programs, eventually reaching all departmental courses and, in the future, courses in all STEM disciplines.

With funding from such sources as the Shodor Foundation, the National Computational Science Institute (NCSI), and the Extreme Science and Engineering Discovery Environment (XSEDE) we have, over the past decade, convened conferences and workshops, involving faculty recognized as pioneers in the area of computational physics education, as well as other physics faculty from around the country, in order to study and address the lack of computational instruction in the undergraduate physics curriculum. One overwhelming reason for the current state of computation in undergraduate physics is the existence of recognizable *barriers* to integrating computation. Below are listed some of the *barriers* that, according to research and faculty experience, hinder the practical inclusion of computation in undergraduate physics courses:

- Undergraduate physics courses are **"locked" to textbooks,** and there are very few textbooks that integrate computational activities and thinking into the traditional format of physics courses (the predominant tool for learning physics is analytical, non-computational theory).
- The **mathematical underpinnings** of computation - numerical instead of analytical - are arguably unfamiliar to traditionally educated physicists, possibly intimidating to some faculty, and counter to what is typically taught in mathematical courses.
- **Institutional impediments** can require personal initiative and risk-taking by individual faculty to implement any kind of non-traditional approach in the classroom, especially a computational approach.
- **Academic impediments**, such as the traditional "lone wolf" mode of assigning a single faculty member to a course, can preclude the integration of computation into courses, whereas a team effort may provide the resource development and support necessary to successfully include computation.
- **Practical barriers** include:
    - lack of computational educational resources sufficiently focused on real classroom needs;
    - faculty time constraints;
    - resistance of a first cadre of students asked to use computation - a change of performance expectations that they did not expect and prepare for.

PICUP has very recently received NSF funding for a national-scale project to address these barriers. It is a 4-year, transformative faculty development project aimed at building and nurturing a community of physics faculty, from a diversity of institutions across the country, who are committed to integrating computation into undergraduate physics courses. Our central strategy includes a faculty development workshop combined with continuing, community-based support for faculty participants who introduce computation into their courses. Crucial to this strategy is the development of computational pedagogical resources that are barrier-lowering in nature, easy to search and interact with, are readily adoptable and adaptable (we want faculty to adapt the materials to their own personal pedagogical preferences), are programming language-agnostic, are developed in a uniform format, and are produced according to current best practices in physics instruction.

We believe that the community building and barrier-lowering aspects of the PICUP approach can eventually serve as a model for all of the STEM disciplines for transforming the way that STEM education is administered. For more information about PICUP and the national-scale computational integration project, go to www.gopicup.org.